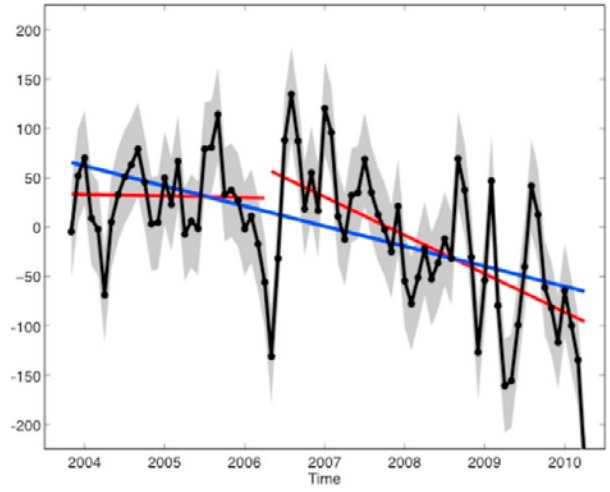
EARTH SCIENCE

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**1,721.9**	**1,760.5**	**1,784.9**	**1,775.5**	**1,835.6**	**1,826.2**	**1,772.8**
Earth Science Research	461.1	440.1	**433.6**	461.7	485.1	497.3	508.1
Earth Systematic Missions	841.2	881.1	**886.0**	787.6	813.2	835.6	756.4
Earth System Science Pathfinder	182.8	188.3	**219.5**	270.9	275.6	224.2	234.4
Earth Science Multi-Mission Operations	147.4	163.4	**161.7**	170.2	172.9	176.5	177.6
Earth Science Technology	52.8	51.2	**49.5**	50.1	52.1	54.1	56.1
Applied Sciences	36.6	36.4	**34.6**	35.0	36.7	38.4	40.1

EARTH SCIENCE RESEARCH

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**461.1**	**440.1**	**433.6**	**461.7**	**485.1**	**497.3**	**508.1**
Earth Science Research and Analysis	299.0	332.3	**324.3**	327.8	336.4	343.7	347.9
Computing and Management	162.1	107.7	**109.3**	133.9	148.7	153.6	160.2
Change From FY 2012 Estimate	--	--	**-6.5**				
Percent Change From FY 2012 Estimate	--	--	**-1.5%**				



Monthly groundwater storage anomalies for the Sacramento and San Joaquin River Basins in millimeters were measured by GRACE from October 2003 to March 2010. The straight sloping dark line represents the overall trend in groundwater storage changes from the 78-month period. These significant changes would not have been measureable by any other means. The lighter gray lines represent the trends from October 2003, March 2006, and April 2006 through March 2010.

NASA Earth Science Research advances understanding of the Earth system, its components and their interactions, its changes, and the consequences of these changes for life. Earth Science Research sponsors basic disciplinary and interdisciplinary research, Earth system modeling efforts, the Airborne Science project (which provides access to aircraft and unmanned aircraft systems), and supercomputing efforts supporting a variety of programs, as well as education and outreach. At least 90 percent of the funds of the program are competitively awarded to investigators from academia, the private sector, and NASA Centers. The program uses satellite and airborne measurements, coupled with cutting-edge analyses and numerical models, to turn observations into information and understanding.

Earth system processes occur on a continuum of spatial and temporal scales and affect weather, climate, air quality, water resources, biodiversity, and other environmental aspects. The program pioneers the use of remote sensing data, primarily space-based, in new and innovative ways, and leverages NASA's unique capabilities in global Earth observation.

NASA takes an organized approach to address complex, interdisciplinary Earth science problems, integrating science across the programmatic elements in pursuit of a comprehensive understanding of the Earth system. The resulting programmatic structure comprises six interdisciplinary and interrelated science focus areas. These areas are:

EARTH SCIENCE RESEARCH

- Climate Variability and Change: understanding the roles of ocean, atmosphere, land, and ice in the climate system and improving predictive capability for future evolution;
- Atmospheric Composition: understanding and improving predictive capability for changes in the ozone layer, climate forcing, and air quality associated with changes in atmospheric composition;
- Carbon Cycle and Ecosystems: quantifying, understanding and predicting changes in Earth's ecosystems and biogeochemical cycles, including the global carbon cycle, land cover, and biodiversity;
- Water and Energy Cycle: quantifying the key reservoirs and fluxes in the global water cycle and assessing water cycle change and water quality;
- Weather: enabling improved predictive capability for weather and extreme weather events; and
- Earth Surface and Interior: characterizing the dynamics of the Earth surface and interior and forming the scientific basis for the assessment and mitigation of natural hazards and response to rare and extreme events.

The research portfolio includes the competed Interdisciplinary Science project, with a focus on research in interdisciplinary areas. Present foci for the Interdisciplinary Science investigations include studies of the physics of the ocean-ice shelf interface and the impacts of urbanization on the environment. The research activities in the project also include the carbon cycle science team, and the Earth science education and outreach activity, directed funding to NASA Centers for Space Geodesy (for development and operation of essential, world-class geodetic networks), high-end computing and scientific computing, and global modeling and data assimilation.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

The revised budget allocations will result in slightly fewer grants to the research community (NASA Centers, universities, private, public, and non-profit sector laboratories) for the analysis and interpretation of data from satellites and field campaigns, as well as decreased effort by NASA investigators in predictive modeling designed to help scientists understand the future evolution of the earth system and its components.

ACHIEVEMENTS IN FY 2011

NASA researchers used data from ICESat's Geoscience Laser Altimeter System and several other NASA satellite data sets to create the most precise map ever produced depicting the amount and location of carbon stored in Earth's tropical forests. The results of this study provide a baseline for ongoing carbon monitoring and research and will serve as a critical resource for managing the carbon in our environment. The research examined information on the height of treetops from more than three million measurements. With the help of corresponding ground data, the amount of above-ground biomass and, thus, the amount of carbon in tropical forests was calculated. These data were then extrapolated over varying landscapes to produce a seamless map, using NASA imagery from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on NASA's Terra spacecraft, the QuikScat scatterometer satellite, and the Shuttle Radar Topography Mission. The new map has provided a benchmark to be used for future comparison of the distribution of carbon stored in forests across more than 75 tropical countries. It shows that the forests in Latin America hold 49 percent of the carbon in the world's tropical forests. For example, Brazil's

carbon stock, at 61 billion tons, almost equals all of the carbon stock in sub-Saharan Africa, at 62 billion tons.

Precision gravity measurements from the GRACE mission were used to quantify unsustainable draw-downs from underground freshwater aquifers. GRACE showed that the Sierra Nevada mountains (California's major water source) and California's Central Valley (America's fruit basket) are experiencing significant rates of groundwater depletion. During the 2003 to 2010 time period studied, the combined Sacramento-San Joaquin River Basins aquifers under the state's Central Valley were drawn down by 25 million acre-feet, almost enough to fill Lake Mead, the Nation's largest freshwater reservoir. The work has resonated across the country, renewing calls for enhanced groundwater management.

Using nine years of NASA satellite measurements of ocean surface temperature, tropical rainfall, and terrestrial forest fire intensity and extent, NASA-funded investigators used the data from the Tropical Rainfall Measuring Mission (TRMM) spacecraft and MODIS on the Terra spacecraft to develop a predictive model relating South American fire season severity to ocean surface temperature anomalies. South American fires are important, owing to their large contributions to global carbon emissions and land-use change. The model enables forecasts of fire conditions with three to five month lead time. The investigation showed that ocean temperature conditions in both the Atlantic and the Pacific contribute (in different ways) to determining the year-to-year variations in fire season severity in South America. The long-lead forecasts enabled by the NASA measurements and research are essential for advancing effective mitigation and adaptation strategies.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

The FY 2013 budget request expands support initiated in FY 2011 and FY 2012 for investigators participating in the National Climate Assessment required under the Global Change Research Act of 1990, including efforts in enabling tools, assessment capabilities and products, and contributing to authorship of the 2013 assessment. NASA-supported investigators will be contributing to the development of sustained assessment capability, as well as the completion of the 2013 report. A particular focus of the research and analysis program in FY 2013 will be on analysis and interpretation of data taken during a series of airborne and shipborne field campaigns taken during the 2010-2012 time period. Several high impact research areas are the motivation and focus of these campaigns. These are:

- Improved understanding of hurricane development and forecasting for evacuation warnings from the hurricane-focused Genesis and Rapid Intensification Processes (GRIP) campaign of late 2010;
- Understanding of the impact of climate change (natural and anthropogenic) on the biogeochemistry and ecology of the Chukchi and Beaufort seas from the ship-based Impacts of Climate change on the Eco-Systems and Chemistry of the Arctic Pacific Environment (ICEScape) held in 2010 and 2011;
- The influence of Asian emissions on clouds, climate, and air quality and the role of the Asian monsoon circulation in governing upper atmospheric composition and chemistry from the multi-aircraft Southeast Asia Composition, Cloud, Climate Coupling Regional Study based in Thailand in late 2012;
- Better understanding of the drivers of changes and fluctuations in salinity and how those changes relate to an acceleration of the global water cycle and climate change based on the Salinity Processes in the Upper Ocean Regional Study in the Atlantic Ocean in late 2012; and

EARTH SCIENCE RESEARCH

- The semi-annual IceBridge campaign, a NASA airborne mission to understand sea level rise and changing sea ice cover. IceBridge begun in 2009, it continues the ICESat time series of ice elevation measurements with Arctic campaigns in the spring and Antarctic in the fall. Finally several airborne campaigns will be carried out as part of the Earth Venture-2 competitive program, targeting a host of science questions such as air quality and carbon cycle science.

BUDGET EXPLANATION

The FY 2013 request is $433.6 million. This represents a $6.5 million decrease from the FY 2012 estimate ($440.1 million).

This decrease in the research and analysis program is due to the reallocation of funding based on Agency priorities.

Projects

EARTH SCIENCE RESEARCH AND ANALYSIS

The Earth Science Research and Analysis collection of projects consists of multiple projects and science teams:

Research and Analysis (R&A) is the core of the research program and funds the analysis and interpretation of data from NASA's satellites, and the scientific activity needed to establish a rigorous base for the satellite data and their use in computational models (for both assimilation and forecasting). R&A also addresses the Earth system and the interactions between its components, characterizing them on a broad range of spatial and temporal scales to understand the naturally occurring and human-induced processes that drive the overall system.

Airborne Science supports NASA's Earth science manned and unmanned aircraft, including operation of a range of NASA-owned and leased aircraft. These assets are used worldwide in campaigns to investigate extreme weather events (e.g., hurricanes), observe Earth system processes, obtain data for Earth science modeling activities, and calibrate instruments flying aboard Earth science spacecraft.

Interdisciplinary Science includes science investigations and calibration and validation activities that ensure the utility of space borne measurements. In addition, it supports focused field work (e.g., airborne campaigns) and specific facility instruments that are heavily relied upon in field work.

Carbon Cycle Science funds research on the distribution and cycling of carbon among the Earth's active land, ocean, and atmospheric reservoirs.

The Global Modeling and Assimilation Office, located at GSFC, creates global climate and Earth system component models using data from Earth science satellites and aircraft. Investigators can then use these products worldwide to further their research.

EARTH SCIENCE RESEARCH

Ozone Trends Science produces a consistent, calibrated ozone time series that can be used for trend analyses and other studies.

Education and Outreach supports NASA's educational goals and communicates the results from Earth science missions and research. It also continues the worldwide implementation and U.S. coordination of the GLOBE program, which is an international collaboration of students and teachers from 111 countries who collect and share information about the health of the environment.

Fellowships and New Investigators support graduate and early career research in the areas of Earth system research and applied science.

Earth Science Directed Research and Technology funds the civil service staff that will work on emerging Earth Science flight projects, instruments and research. The workforce and funding will transfer to projects by the beginning of FY 2013.

Space Geodesy provides global geodetic positioning and support for geodetic reference frames necessary for climate change and geohazards research and applications and their associated missions.

COMPUTING AND MANAGEMENT

To turn data into information and information into knowledge, NASA's supercomputers are used to analyze NASA satellite or telescope observations (e.g., understanding the cloud and climate feedback and discovering exoplanets using Kepler data) and develop and validate fundamental theories (e.g. the interactions between atmosphere, land and ocean).

The Computing and Management collection of projects consists of three projects:

High-End Computing Capability (HECC) is a project at ARC that is focused around the Columbia and Pleiades supercomputer systems and the associated network connectivity, data storage, data analysis, visualization, and application software support. SMD currently funds and manages HECC resources, which serve the supercomputing needs of all NASA mission directorates and NASA-supported principal investigators at universities. SMD funding supports the operation, maintenance, and upgrade of NASA's supercomputing capability, while the Strategic Capabilities Assets Program exercises oversight and insight functions. The two systems, with a total of about 117,500 computer processor cores, support NASA's aeronautics, human exploration, space operation, and science missions.

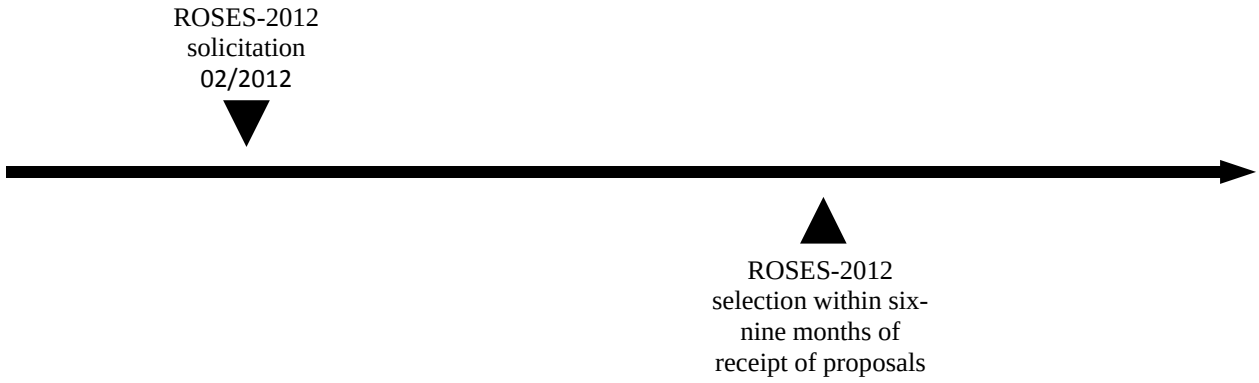
Scientific Computing funds NASA's Earth Science Discover computing system, software engineering, and user interface projects at GSFC, including climate assessment modeling carried out at the Goddard Institute for Space Studies. Scientific Computing supports Earth science modeling activities based on data collected by Earth science spacecraft. The system is separate from the HECC so it can be close to the satellite data archives at GSFC. The proximity to the data and the focus on satellite data assimilation makes the Discover cluster unique in the ability to analyze large volume of satellite data quickly. The system currently has a total of about 31,400 computer processor cores.

EARTH SCIENCE RESEARCH

Directorate Support funds SMD institutional and cross-cutting activities, including: National Academies studies, proposal peer review processes, printing and graphics, IT, the NASA Postdoctoral Fellowship program, working group support, independent assessment studies, and other administrative tasks.

Program Schedule

The Earth Science research program is implemented via competitively selected research. Research solicitations are released each year in the Research Opportunites in Space and Earth Sciences NASA Research Announcements (ROSES NRA), typically aiming to initiate research for about one third of the program, given the selected projects are typically three-year awards. Therefore, FY 2013 funds will be allocated to first year projects from ROSES-2012 selections, second year of projects from ROSES-2011 selections, and third year of projects from FY 2010 selections.



EARTH SCIENCE RESEARCH

Program Management & Commitments

The Earth Science theme manages the research program. GSFC implements scientific computing and ARC implements HECC.

Project/Element	Provider
R&A	Provider: SMD Project Management: HQ NASA Center: HQ Cost Share: US Global Change Research Program (USGCRP) and Subcommittee on Ocean Science and Technology (SOST) agencies
Interdisciplinary Science	Provider: SMD Project Management: HQ NASA Center: HQ Cost Share: USGCRP and SOST agencies
Carbon Cycle Team	Provider: SMD Project Management: HQ NASA Center: GSFC, JPL, ARC Cost Share: USGCRP and SOST agencies
Ozone Trends Science	Provider: SMD Project Management: HQ NASA Center: GSFC, LaRC Cost Share: USGCRP and SOST agencies
Airborne Science	Provider: SMD Project Management: HQ NASA Center: GSFC, DFRC, ARC Cost Share: FAA, DOD, DOE, NSF, NOAA
High End Computing Capability	Provider: SMD Project Management: HQ NASA Center: ARC Cost Share: DoD, DOE
Scientific Computing	Provider: SMD Project Management: HQ NASA Center: GSFC Cost Share: DoD, DOE

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Project/Element	Provider
Global Modeling and Assimilation Office	Provider: SMD Project Management: HQ NASA Center: GSFC Cost Share: N/A
Space Geodesy	Provider: SMD Project Management: HQ NASA Center: GSFC, JPL Cost Share: N/A
ES Education and Outreach Activity	Provider: SMD, intra-agency Project Management: HQ NASA Center: All Cost Share: N/A
Fellowships and New Investigators	Provider: SMD, intra-agency Project Management: HQ NASA Center: All Cost Share: N/A

Acquisition Strategy

The R&A project constitutes the core of the NASA Earth Science Research program and accounts for about half of its total budget. Investigations are primarily competed via the annual SMD ROSES solicitations. ROSES-2012, planned for release in February 2012, will result in grants funded with FY 2013 funding and two subsequent years. The Earth Science Research program is based on full and open competition, and at least 90 percent of the funds of the program are competitively awarded to investigators from academia, the private sector, and NASA Centers. All proposals in response to NASA ROSES and other related announcements are peer reviewed and selected based on defined criteria. Additionally, the program continues the funding of research tasks solicited in prior year ROSES solicitations as they progress into their subsequent years.

EARTH SCIENCE RESEARCH

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	NASA Advisory Council (NAC) Earth Science Subcommittee (ESS)	2011	NAC ESS reviews progress towards Earth Science objectives in the NASA Strategic Plan annually. During its 2011 meeting, the ESS reviewed and rated the Earth Science Division science metrics based on submitted accomplishments and peer-reviewed publications for FY 2011 in support of reporting requirements of the Government Performance and Results Act (GPRA) Modernization Act of 2010. All six science focus areas were rated "green" as documented in the FY 2011 Performance and Accountability Report. The next review is scheduled for 2012.	2012

EARTH SYSTEMATIC MISSIONS

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**841.2**	**881.1**	**886.0**	**787.6**	**813.2**	**835.6**	**756.4**
Global Precipitation Measurement (GPM)	133.6	92.9	**88.0**	66.2	19.1	18.1	10.2
Landsat Data Continuity Mission (LDCM)	166.0	159.3	**54.7**	2.1	2.1	2.2	2.3
Ice, Cloud, and land Elevation Satellite (ICESat-II)	59.7	120.5	**157.2**	145.4	89.7	92.7	14.1
Soil Moisture Active and Passive (SMAP)	92.5	176.3	**237.4**	89.1	86.7	15.9	11.3
Other Missions and Data Analysis	389.5	332.0	**348.7**	484.7	615.7	706.7	718.5
Change From FY 2012 Estimate	--	--	**4.9**				
Percent Change From FY 2012 Estimate	--	--	**0.6%**				

On August 27, 2011, Hurricane Irene's center was still over eastern North Carolina. This visible image was captured by the MODIS instrument on NASA's Aqua satellite.

Earth Systematic Missions (ESM) includes a broad range of multi-disciplinary science investigations aimed at developing a scientific understanding of the Earth system and its response to natural and human-induced forces and changes. Understanding these forces will help in determining how to predict future changes, possibly to mitigate them if possible, and how to adapt where mitigation is not possible. The regional consequences of these forces e.g. changes in precipitation patterns, length of growing seasons, severity of storms, change of sea level, must be understood to determine which aspects of climate change are most harmful and how to adapt to those changes that cannot be mitigated.

The ESM program develops Earth observing research satellite missions, manages the operation of NASA facility research missions once on orbit, and produces standard mission products in support of NASA and National research, applications, and policy communities.

Interagency and international partnerships are a central element throughout the ESM program. Several of the on-orbit missions provide data products in near-real time for use by U.S. and international meteorological agencies and disaster responders. Five of the on-orbit missions involved significant international or interagency collaboration in development, and a four satellite A-Train formation flying constellation (Aqua, CloudSat, CALIPSO, and Aura) consists of both NASA and international missions.

EARTH SYSTEMATIC MISSIONS

One of the six ESM program's foundational missions presently in development involve interagency collaboration (LDCM), while two others are joint projects with international partners: GPM is being done in cooperation with the Japanese Aerospace Exploration Agency (JAXA) and the GRACE Follow On (GRACE-FO) mission is a partnership between NASA and the German Space and Earth Science agencies.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

The program has adjusted the mission timelines and budgets to accommodate increasing launch vehicle costs (for SMAP) and the reallocation of funding based on Agency priorities. The SMAP launch date and funding profile is driven by launch vehicle availability and the current plan supports an early FY 2015 launch. The Agency continues with the pre-formulation studies, formulation, and development of other Decadal and climate missions such as DESDynI, GRACE FO, SWOT, PACE, and on pre-formulation studies for the OCO-3 instrument, CLARREO, ASCENDS, ACE, GEO-CAPE, and HypIRI. However, several of these projects will be delayed, some by a year and others two or more years.

ACHIEVEMENTS IN FY 2011

LDCM made progress towards completing the development phase (Phase C) and beginning the integration and test phase (Phase D). Progress toward completion of the spacecraft development culminated with the Systems Integration Review (SIR) during the fourth quarter of FY 2011 in preparation for instrument integration onto the LDCM observatory. Development and test of one of the two main instruments, the Operational Land Imager (OLI), was completed in preparation for delivery and integration onto the Observatory. The Thermal Infrared Sensor (TIRS) has completed development of the instrument and began environmental testing during the fourth quarter of FY 2011.

The GPM GMI instrument Pre-Environmental Review was successfully completed and environmental testing was initiated in the fourth quarter of FY2011. Additionally, the ground system-Precipitation Processing System (PPS) Build 3 review was held, and a propulsion system integration to the Core Observatory was completed.

SMAP successfully passed the Key Decision Point-B (KDP-B) review in January 2010, and is now in Phase B of the mission. Phase B has a strong emphasis on risk reduction, and on requirements and interface maturation. In FY2011 SMAP has completed the Preliminary Design Reviews for the flight system, instrument and spacecraft in preparation for the mission system PDR.

Suomi NPP, formerly the NPOESS Preparatory Project or NPP, is the next spacecraft in the nation's future polar operational meteorological satellite systems. In FY 2011 all of the remaining instruments were delivered to the spacecraft and Suomi NPP completed its Phase D assembly integration and test activities in preparation for a launch in October 2011. Suomi NPP is a NASA research mission involving a collaboration between NASA, NOAA, and DoD, designed to extend selected scientific data sets initiated by the NASA Earth Observing System and to serve as risk reduction demonstrations for key instruments to be used

EARTH SYSTEMATIC MISSIONS

ICESat-2 successfully completed its Phase A activities and passed its KDP-B review. The spacecraft vendor was selected in August 2011.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

NASA will complete environmental testing for LDCM and will deliver it to the launch site in early first quarter FY 2013 in preparation for launch. The launch is currently scheduled for January 25, 2013 with an initial 90-day on-orbit checkout and commissioning.

The GPM project will complete its GPM Core Observatory and complete the environmental testing. NASA will prepare the core observatory for shipment to Japan for its launch.

In FY 2013, SMAP will pursue development and implementation activities and milestone reviews targeting an estimated launch in October 2014. The project will also conduct the Systems Integration Review.

In FY 2013, the ICESat-2 spacecraft will undergo its Critical Design Review (CDR). The SAGE III instrument will conduct its development phase C and complete the instrument CDR.

The GRACE FO mission will complete Phase B.

BUDGET EXPLANATION

The FY 2013 request is $886.0 million. This represents a $4.9 million increase from the FY 2012 estimate ($881.1 million).

This increase is primarily due to the ramp up of SMAP and ICESat-2 mission activities and launch vehicles costs.

Projects

The six current flight missions in formulation or development contained in the ESM program are the GPM, LDCM, ICESat-2, SMAP, SAGE III, and GRACE FO. Detailed information about each of the projects is outlined separately.

Also included within the ESM program is a group of projects and activities collectively called “Other Missions and Data Analysis.” This group includes many operating missions. Detailed information about each of the projects is outlined separately.

GLOBAL PRECIPITATION MEASUREMENT (GPM)

Formulation	Development	Operations

FY 2013 BUDGET

Budget Authority (in $ millions)	Prior	Actual FY 2011	Estimate FY 2012	**FY 2013**	FY 2014	FY 2015	FY 2016	FY 2017	BTC	LCC Total
FY 2013 President's Budget Request	504.8	133.6	92.9	**88.0**	66.2	19.1	18.1	10.2	0.0	932.8
2012 MPAR Project Cost Estimate	**504.8**	**133.6**	**92.9**	**88.0**	**66.2**	**19.1**	**18.1**	**10.2**	**0.0**	**932.8**
Formulation	349.2	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	349.2
Development/ Implementation	155.6	133.6	92.9	**88.0**	44.5	3.2	1.5	0.0	0.0	519.3
Operations/close-out	0.0	0.0	0.0	**0.0**	21.6	15.9	16.6	10.2	0.0	64.3
Change From FY 2012 Estimate		--	--	**-4.9**						
Percent Change From FY 2012 Estimate		--	--	**-5.3%**						

The upcoming Global Precipitation Measurement mission (artist's conception shown) will provide improved measurements of rain and snow globally. The data can reveal new information on hurricane eyewall development and intensity changes, measure hazard-triggering rainfall events contributing to flooding and landslides, provide inputs to climate, weather, and land surface models for improved predictions, and offer new insights into agricultural productivity and world health.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

In October 2011, GPM received approval for a re-plan with a launch delay. This delay from July 2013 to June 2014 was due to development delays of the NASA-developed spacecraft bus and GPM Microwave Imager (GMI) and development delays of the JAXA-supplied Dual-frequency Precipitation Radar (DPR), due in part to the impact of the March 2011 earthquake in Japan.

PROJECT PURPOSE

The GPM mission will advance the measurement of global precipitation, making possible high spatial resolution precipitation measurements. A joint mission with JAXA, GPM will provide the first opportunity to calibrate measurements of global precipitation (including the distribution, amount, rate, and associated heat released) across tropical, mid-latitude, and polar regions.

GLOBAL PRECIPITATION MEASUREMENT (GPM)

Formulation	Development	Operations

The GPM mission has several scientific objectives:

- Advance precipitation measurement capability from space through combined use of active and passive remote-sensing techniques. These advanced measurements will be used to calibrate dedicated and operational passive microwave sensors with the goal of achieving global sampling;
- Advance understanding of global water/energy cycle variability and fresh water availability. Improved measurements of the space-time variability of global precipitation will substantially close the water/energy budget and elucidate the interactions between precipitation and other climate parameters;
- Improve climate prediction by providing the foundation for better understanding of surface water fluxes, soil moisture storage, cloud/precipitation microphysics and latent heat release in Earth's atmosphere;
- Advance numerical weather prediction skills through more accurate and frequent measurements of instantaneous rain rates with better error characterizations, and the development of improved data assimilation methods; and
- Improve flood-hazard and fresh water-resource prediction capabilities through better temporal sampling and wider spatial coverage of high-resolution precipitation measurements, and innovative designs in hydro-meteorological modeling. Such innovation includes understanding the quantitative nature and physical causes of differences in surface fluxes simulated by hydro-meteorological models operating in different modes.

For more information see http://science.hq.nasa.gov/missions/earth.html.

PROJECT PARAMETERS

The NASA-provided element of the GPM project includes a Core Observatory spacecraft and a GMI. The Core Observatory will leverage passive microwave measurements from other operating and planned "satellites of opportunity" by calibrating their measurements to its own. The exact sampling rate over different areas of the globe will depend on the number and orbits of the satellites of opportunity, but given the prevalence of passive microwave instruments on operational satellite systems, the global sampling will be robust. The Core Observatory includes two scientific instruments which will provide active and passive microwave measurements of precipitation.

The GMI instrument is a conically scanning radiometer that will provide significantly improved spatial resolution over the TRMM Microwave Imager. The satellites of opportunity will fly at multiple altitudes and inclinations.

The JAXA-supplied DPR instrument has cross-track swath widths of 245 kilometers and 120 kilometers, in Ku-band and Ka-band, providing three-dimensional observation of rain and an accurate estimation of rainfall rate. The KuPR (13.6 gigahertz) subsystem of the DPR is an updated version of the highly successful radar flown on TRMM.

The Core Observatory with both the GMI and the DPR will be launched from Tanegashima Space Center, Japan on a JAXA-provided HIIA launch vehicle. DPR and GMI data will be relayed using the TDRSS

GLOBAL PRECIPITATION MEASUREMENT (GPM)

Formulation	Development	Operations

multiple access and single access services. The NASA Core Observatory will fly in a 65 degree inclined orbit at an altitude of 407 kilometers; the 65 degree orbit provides improved latitude coverage over the TRMM (which is 35 degrees).

ACHIEVEMENTS IN FY 2011

During FY 2011, the GMI instrument Pre-Environmental Review was successfully completed. Additionally, the ground system- PPS Build 3 review was held, and a propulsion system integration to the Core Observatory was completed.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

NASA will complete the environmental testing for the core observatory and will be prepare it for shipment to Japan for its launch.

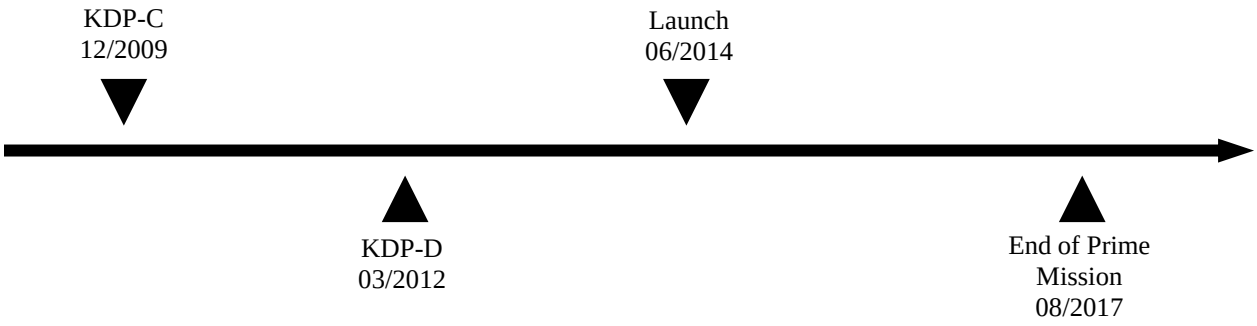
SCHEDULE COMMITMENTS/KEY MILESTONES

Development Milestones	Confirmation Baseline Date	FY 2013 PB Request Date
KDP-C	Dec-09	Dec-09
KPD-D	Mar-12	Mar-12
Launch	Jul-13	Jun-14
End of Prime Mission	Sep-16	Aug-17

GLOBAL PRECIPITATION MEASUREMENT (GPM)

Formulation	Development	Operations

Project Schedule



Development Cost and Schedule

Due to the mission's critical international partnership and the desire to maintain continuity of the precipitation record established by the long-lived TRMM, NASA and JAXA will strive to launch GPM in February 2014. The GPM project has been directed to execute all necessary actions to accomplish the February 2014 launch. Consistent with NASA policies regarding commitments to cost and schedule, the GPM launch shall be no later than June 2014.

Base Year	Base Year Development Cost Estimate ($M)	JCL (%)	Current Year	Current Year Development Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
2010	555.2	70	2012	519.3	-6.5%	Launch Readiness	Jul-13	Jun-14	11

Note: *The confidence level estimates reported reflect an evolving process as NASA improves its probabilistic estimation techniques and processes. The estimate above reflects the practices and policies at the time it was developed. Estimates that include combined cost and schedule risks are denoted as joint confidence level; all other confidence levels reflect cost confidence without necessarily factoring the potential impacts of schedule changes on cost.*

GLOBAL PRECIPITATION MEASUREMENT (GPM)

Formulation	Development	Operations

Development Cost Details (in $M)

Reductions in the Total, Payloads, Ground Systems, Science/Technology, and Other Direct Project Costs lines are due to the elimination of the Low-Inclination Observatory GMI-2 instrument, associated TDRSS communications subsystem, payload accommodation, ground system, and operations costs in 2012. Increases in the Aircraft/Spacecraft and Systems I&T lines are due to spacecraft development issues and the extension of integration and testing activities supporting the replanned launch readiness date.

Element	Base Year Development Cost Estimate	Current Year Development Cost Estimate	Change from Base Year Estimate
TOTAL:	**555.2**	**519.3**	**-35.9**
Aircraft/Spacecraft	151.2	230.2	79.0
Payloads	91.2	83.1	-8.1
Systems I&T	6.8	11.7	4.9
Launch Vehicle	1.5	1.8	0.3
Ground Systems	30.5	29.4	-1.1
Science/Technology	28.4	28.0	-0.4
Other Direct Project Costs	245.6	135.0	-110.6

Project Management & Commitments

GSFC has project management responsibility. GPM, initiated by NASA and JAXA as a global successor to TRMM, comprises a consortium of international space agencies, including Centre National d'Etudes Spatiales (CNES), Indian Space Research Organization (ISRO), NOAA, European Organisation for the Exploitation of Meterological Satellite (EUMETSAT), and others.

GLOBAL PRECIPITATION MEASUREMENT (GPM)

Formulation	Development	Operations

Project/Element	Provider	Description	FY 2012 PB	FY 2013 PB
Core Observatory	Provider: GSFC Project Management: GSFC NASA Center: GSFC Cost Share:	Provides platform for the GMI and JAXA-supplied DPR instruments.	Same	Same
Core Observatory GMI	Provider: GSFC Project Management: GSFC NASA Center: GSFC Cost Share:	Provides 13 microwave channels ranging in frequency from 10 GHz to 183 GHz; four high frequency, millimeter-wave, channels	Same	Same
Core Observatory DPR	Provider: JAXA Project Management: JAXA NASA Center: Cost Share: JAXA	Provides cross-track swath widths of 245 and 120 kilometers, for the Ku precipitation radar (KuPR) and Ka-band precipitation	Same	Same
Launch vehicle and services	Provider: JAXA Project Management: NASA Center: Cost Share: JAXA	H-IIA	Same	Same
Ground System	Provider: GSFC Project Management: GSFC NASA Center: GSFC Cost Share: JAXA	Provides control of Core Observatory operations, science data processing, and distribution.	Same	Same

GLOBAL PRECIPITATION MEASUREMENT (GPM)

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: Instrument deliveries are further delayed, Then: GPM integration and testing schedule reserve would be reduced.	Flexibility in integration and testing plans allow schedule modifications to allow delivery delays. Implement extended shifts and weekend work to recover schedule.

Acquisition Strategy

MAJOR CONTRACTS/AWARDS

The GPM instrument was selected through open competition in FY 2005.

Element	Vendor/Provider	Location
GMI	Ball Aerospace and Technologies Corp.	Boulder, CO
DPR	JAXA provided	
GPM Core Spacecraft	GSFC	Greenbelt, MD
Launch Vehicle	JAXA provided	

INDEPENDENT REVIEWS

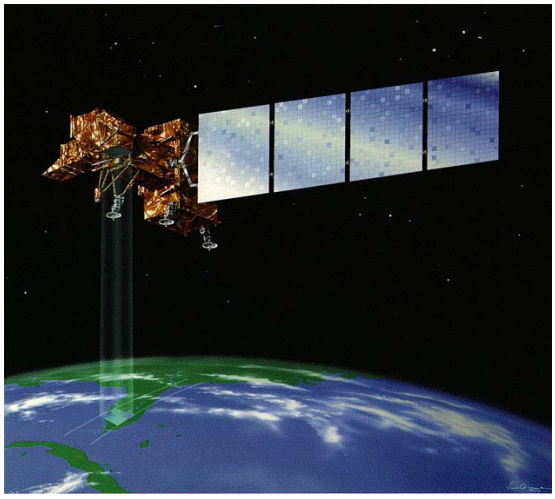
Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	Dec-09	Systems Integration Review (SIR)	Feb-12
Performance	HQ and GSFC	N\A	Key Decision Point D (KDP-D)	Mar-12

LANDSAT DATA CONTINUITY MISSION (LDCM)

Formulation	Development	Operations

FY 2013 BUDGET

Budget Authority (in $ millions)	Prior	Actual FY 2011	Estimate FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	BTC	LCC Total
FY 2013 President's Budget Request	**541.2**	**166.0**	**159.3**	**54.7**	**2.1**	**2.1**	**2.2**	**2.3**	**1.3**	**931.2**
2012 MPAR Project Cost Estimate	**541.2**	**166.0**	**159.3**	**54.7**	**2.1**	**2.1**	**2.2**	**2.3**	**1.3**	**931.2**
Formulation	341.4	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	341.4
Development/ Implementation	199.8	166.0	159.3	**52.1**	0.0	0.0	0.0	0.0	0.0	577.2
Operations/close-out	0.0	0.0	0.0	**2.6**	2.1	2.1	2.2	2.3	1.3	12.5
Change From FY 2012 Estimate		--	--	**-104.6**						
Percent Change From FY 2012 Estimate		--	--	**-65.7%**						



Landsat satellites have taken specialized digital photographs of Earth's continents and surrounding coastal regions for over three decades. Landsat data have been used to monitor water quality, glacier recession, sea ice movement, invasive species encroachment, coral reef health, land use change, deforestation rates and population growth. Observations from the Landsat satellites have also helped to assess damage from natural disasters such as fires, floods, and tsunamis, and subsequently, plan disaster relief and flood control programs.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

The project has made excellent progress with delivery of the Operational Land Imager (OLI) and integration with the spacecraft as well as completion of the Thermal InfraRed Sensor (TIRS) environmental testing. The LDCM budget is reduced by $10.4 million reflecting the retirement of key cost risks associated with these accomplishments.

PROJECT PURPOSE

The purpose of LDCM is to extend the record of multi-spectral, moderate resolution Landsat-quality data and to meet government operational and scientific requirements for observing land use and land change.

Unprecedented changes in land cover and use are having profound consequences for weather and climate change, ecosystem function and services, carbon cycling and sequestration, resource management, the national and global economy,

LANDSAT DATA CONTINUITY MISSION (LDCM)

Formulation	Development	Operations

human health, and society. The Landsat data series, begun in 1972, is the longest continuous record of changes in Earth's surface as seen from space and the only satellite system designed and operated to repeatedly observe the global land surface at moderate resolution. Landsat data are now available at no cost, providing a unique resource for people who work in agriculture, geology, forestry, regional planning, education, mapping, and global climate change research.

For more information, see: http://ldcm.nasa.gov.

PROJECT PARAMETERS

LDCM consists of a two science instruments (the Operational Land Imager and the Thermal Infrared Sensor), a spacecraft, and a mission operations element. LDCM is in implementation and system level requirements are baselined to provide the following system-level performance parameters:

- Earth Spatial-Temporal Coverage: 16-day repeat coverage of the global land mass;
- Spatial Resolution: 30 meters (visible, near infrared, shortwave infrared), 120 meters (thermal); 15 meters (panchromatic);
- Radiometric Performance: accuracy, dynamic range, and precision sufficient to detect land cover change using historic Landsat data;
- Data: 185-kilometer cross track-by-180-kilometer along track multi-spectral image of Earth's surface; and
- Mission Life: five years.

ACHIEVEMENTS IN FY 2011

In FY 2011, the LDCM project made progress towards completing the development phase (Phase C) and beginning the integration and test phase (Phase D). Progress toward completion of the spacecraft development culminated with the systems integration review in the fourth quarter of FY 2011 in preparation for instrument integration onto the LDCM observatory. Development and test of one of the two main instruments, the OLI, was completed in preparation for delivery and integration onto the observatory. The project has completed development of TIRS and is currently in the environmental test phase as of the fourth quarter of FY 2011.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

NASA will complete the integration and test phase for the LDCM observatory in FY 2012 and deliver it to the launch site in early FY 2013 in preparation for launch. The launch is currently scheduled for January 25, 2013, with an initial 90-day on-orbit checkout and commissioning.

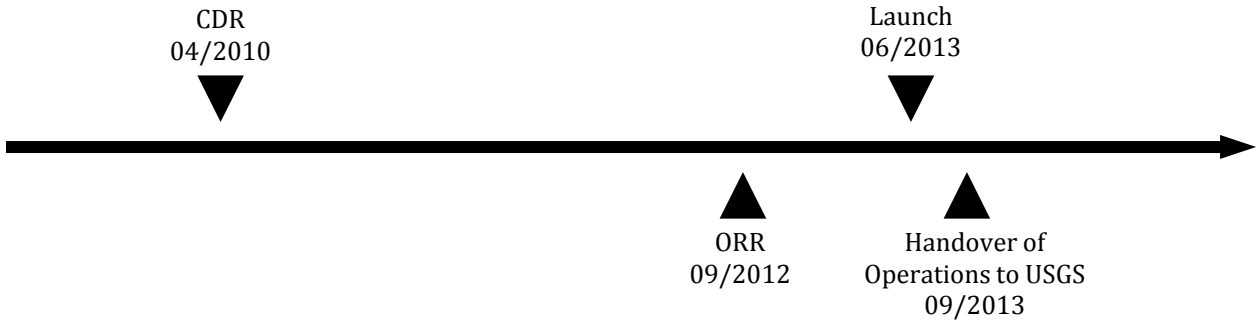
LANDSAT DATA CONTINUITY MISSION (LDCM)

Formulation	Development	Operations

SCHEDULE COMMITMENTS/KEY MILESTONES

Development Milestones	Confirmation Baseline Date	FY 2013 PB Request Date
CDR	Apr-10	Apr-10
ORR	Sep-12	Sep-12
Launch	Jun-13	Jun-13
Handover of Operations to USGS	Sep-13	Sep-13

Project Schedule



LANDSAT DATA CONTINUITY MISSION (LDCM)

Formulation	Development	Operations

Development Cost and Schedule

The LDCM project has been directed to execute all necessary actions to accomplish the January 2013 launch. Consistent with NASA policies regarding commitments to cost and schedule, the LDCM launch shall be no later than June 2013.

Base Year	Base Year Development Cost Estimate ($M)	JCL (%)	Current Year	Current Year Development Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
2010	583.4	70	2012	577.2	-1.1	Launch Readiness	Jun-13	Jun-13	0

Note: *The confidence level estimates reported reflect an evolving process as NASA improves its probabilistic estimation techniques and processes. The estimate above reflects the practices and policies at the time it was developed. Estimates that include combined cost and schedule risks are denoted as joint confidence level; all other confidence levels reflect cost confidence without necessarily factoring the potential impacts of schedule changes on cost.*

Development Cost Details (in $M)

The major change in the development cost was an exchange of responsibilities with USGS for the development of the ground system, resulting in an increase in the ground systems development cost but offset by a reduction in operations costs. Minor changes included increases for the development of the two science instruments, increased support for systems integration and testing, and a redistribution of project funds across the project elements.

Element	Base Year Development Cost Estimate	Current Year Development Cost Estimate	Change from Base Year Estimate
TOTAL:	**583.4**	**577.2**	**-6.2**
Aircraft/Spacecraft	116.7	106.1	-10.6
Payloads	131.3	147.0	15.7
Systems I&T	1.7	2.1	0.4
Launch Vehicle	126.4	128.1	1.7
Ground Systems	10.7	13.7	3.0
Science/Technology	13.3	8.7	-4.6
Other Direct Project Costs	183.3	171.5	-11.8

LANDSAT DATA CONTINUITY MISSION (LDCM)

Formulation	Development	Operations

Project Management & Commitments

LDCM is being developed in cooperation with the USGS and managed by GSFC. When LDCM reaches orbit and is deployed, operations responsibilities will be transferred to USGS.

Project/Element	Provider	Description	FY 2012 PB	FY 2013 PB
Operational Land Imager	Provider: Ball Aerospace Project Management: GSFC NASA Center: GSFC Cost Share: None	Provide moderate resolution, multi-channel, wide swath visible imaging of Earth's surface, consistent with previous LandSat missions.	Same	Same
Thermal Infrared Sensor	Provider: GSFC Project Management: GSFC NASA Center: GSFC Cost Share: None	Provide Landsat equivalent thermal infrared data and extend Landsat data series for three years.	Same	Same
Spacecraft	Provider: Orbital Sciences Corporation Project Management: GSFC NASA Center: GSFC Cost Share: None	Platform to provide performance commensurate with OLI and TIRS requirements.	Same	Same
Ground System	Provider: USGS Project Management: USGS NASA Center: GSFC Cost Share: USGS	Provide Landsat equivalent data series and extend Landsat data for five years.	Same	Same
Mission Operations Element	Provider: Hammers Corp, Project Management: GSFC NASA Center: GSFC Cost Share: USGS	Provide software and system for capability for command and control, mission scheduling, long-term trending and flight dynamics analysis.	Same	Same

LANDSAT DATA CONTINUITY MISSION (LDCM)

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: TIRS development is behind schedule due to late addition of sensor to the instrument complement, Then: TIRS will not be delivered on schedule.	Management developed alternate observatory integration and test scenarios to allow for late arrival of TIRS. A flyable mass model has been developed if TIRS is not delivered per the required schedule.

Acquisition Strategy

The LDCM instrument builder was selected through open competition in FY 2007. The Ball Aerospace and Technologies Corporation is building the OLI instrument. LDCM spacecraft uses the Rapid Spacecraft Development Office (RSDO) selection process, and selected General Dynamics (now Orbital Sciences Corporation). The TIRS instrument was a directed development, assigned to the GSFC and is being built in-house at GSFC.

MAJOR CONTRACTS/AWARDS

Element	Vendor/Provider	Location
OLI	Ball Aerospace and Technology, Corp.	Boulder, CO
TIRS	GSFC	Greenbelt, MD
Spacecraft	Orbital Sciences Corporation	Gilbert, AZ
Launch Vehicle	ULA	Centennial, CO
Mission Operations Element	Hammers, Corp.	Greenbelt, MD

LANDSAT DATA CONTINUITY MISSION (LDCM)

Formulation	Development	Operations

INDEPENDENT REVIEWS

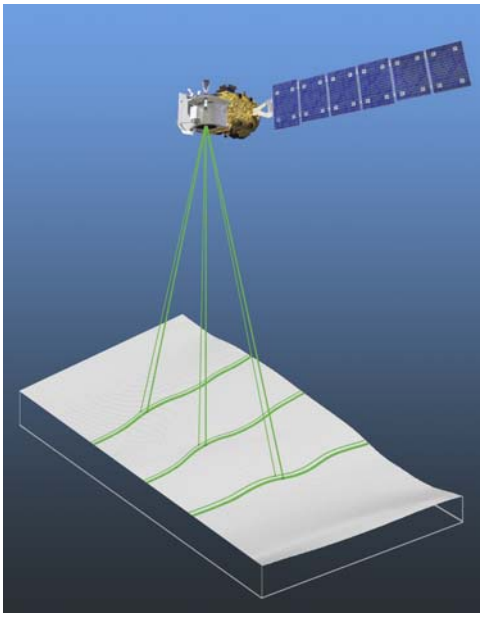
Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	N/A	Operations Readiness Review	Oct-12

ICE, CLOUD, AND LAND ELEVATION SATELLITE (ICESAT)-2

Formulation	Development	Operations

FY 2013 BUDGET

Budget Authority (in $ millions)	Prior	Actual FY 2011	Estimate FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**87.2**	**59.7**	**120.5**	**157.2**	**145.4**	**89.7**	**92.7**	**14.1**
Change From FY 2012 Estimate		--	--	**36.7**				
Percent Change From FY 2012 Estimate		--	--	**30.5%**				



ICESat-2, among other observations, will monitor polar ice levels that scientists believe to be an indicator of climate change. ICESat-2 will use a laser-ranging, light detection and ranging technique to measure the topography of the Greenland and Antarctic ice sheets as well as the thickness of Arctic and Antarctic sea ice. The satellite LIDAR also will measure vegetation canopy heights and support other NASA environmental monitoring missions.

PROJECT PURPOSE

ICESat-2 is the second-generation of the laser altimeter ICESat mission, launched by NASA in January 2003. ICESat-2 will continue the measurements begun with the ICESat mission, but will improve upon the first ICESat design by incorporating a micro-pulse multi-beam laser to provide dense cross-track sampling, improving elevation estimates over inclined surfaces and very rough (e.g., crevassed) areas and improving lead detection for sea ice freeboard estimates. ICESat-2 is a Tier-1 decadal survey mission that entered formulation in FY 2010 and is being developed for a target launch in 2016.

Some of the key science objects are to:

- Quantify polar ice-sheet contributions to current and recent sea-level change and the linkages to climate conditions;
- Quantify regional signatures of ice-sheet changes to assess mechanisms driving those changes and improving predictive ice sheet models;
- Estimate sea-ice thickness to examine ice/ocean/atmosphere exchanges of energy, mass, and moisture; and
- Measure vegetation canopy height as a basis for estimating large-scale biomass and biomass change.

For more information, see http://icesat.gsfc.nasa.gov/icesat2.

ICE, CLOUD, AND LAND ELEVATION SATELLITE (ICESAT)-2

Formulation	Development	Operations

EXPLANATION OF PROJECT CHANGES

Since entering the early formulation phase, the project has revised its launch vehicle implementation approach and is now pursuing a co-manifested launch vehicle. The planned launch date range is April to November 2016. The change in the launch date range has led to an increase of the estimated life cycle cost.

PROJECT PRELIMINARY PARAMETERS

The ICESat-2 observatory employs a dedicated spacecraft with a multi-beam photon-counting surface elevation lidar. It will be launched into a 495 kilometer, 94 degree, 91 day repeat orbit.

The ICESat-2 project is working toward a mature (Technology Readiness Level – 6) baseline instrument concept in preparation for formal mission confirmation (KDP-C) at the end of FY 2012. This includes the photon-counting approach to provide cross-track measurement capabilities. As part of this engineering process, the project has used and will continue to use an airborne instrument to simulate the space-based measurements to optimize the final instrument design and to develop algorithms. Based on cost and schedule analysis of the ICESat-2 preliminary design, a baseline budget and launch readiness date will be established at mission confirmation.

ACHIEVEMENTS IN FY 2011

In FY 2011, ICESat-2 successfully completed KDP-B. The spacecraft vendor was selected in August 2011. ICESat-2's sensor successfully completed its instrument Preliminary Design Review (PDR) in December 2011.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

In FY 2013, the spacecraft will undergo its Critical Design Review (CDR).

ESTIMATED PROJECT SCHEDULE

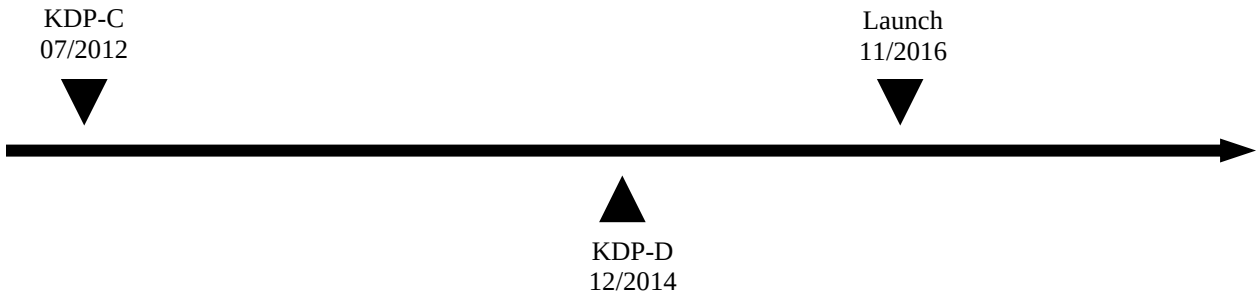
ICESat-2 is planned for launch within April to November 2016 for a three-year prime mission.

ICE, CLOUD, AND LAND ELEVATION SATELLITE (ICESAT)-2

Formulation	Development	Operations

Development Milestones	Formulation Agreement Estimate	FY 2013 PB Request Date
KDP-C	Jul-12	Jul-12
KDP-D	Dec-14	Dec-14
Launch	Nov-16	Nov-16

Project Schedule



Formulation Estimated Life Cycle Cost Range and Schedule Range Summary

LCC estimates are preliminary. A Baseline cost commitment does not occur until KDP-C, following a Non-Advocate Review and/or Preliminary Design Review.

KDPB Date	Estimated Life Cycle Cost Range ($M)	Key Milestone	Key Milestone Estimated Date Range
Jul-11	686-776	Launch Readiness	4/2016-11/2016

ICE, CLOUD, AND LAND ELEVATION SATELLITE (ICESAT)-2

Formulation	Development	Operations

Project Management & Commitments

GSFC has project management responsibility for ICESat-2.

Project/Element	Provider	Description	FY 2012 PB	FY 2013 PB
Atlas Instrument	Provider: GSFC Project Management: GSFC NASA Center: GSFC Cost Share: N/A	Advanced Topographic Laser Altimeter System	TBD	New
Spacecraft	Provider: Orbital Science Corporation Project Management: GSFC NASA Center: GSFC Cost Share: None	Provides platform for the instrument	TBD	New
Ground System	Provider: Orbital Science Corporation Project Management: GSFC NASA Center: GSFC Cost Share: None	Provides control of Observatory operations, science data processing, and distribution.	N/A	New
Launch Vehicle	Provider: TBD Project Management: TBD NASA Center: KSC Cost Share: TBD	TBD	Same	Same

ICE, CLOUD, AND LAND ELEVATION SATELLITE (ICESAT)-2

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: A dual manifest launch has been baselined, Then: A delay or failure to secure a dual manifest agreement would force the project outside the current planned budget.	Continue to work with potential co-manifest partners to secure an agreement for a shared launch. Develop off-ramps and options if dual manifest milestones are not achieved.

Acquisition Strategy

The ICESat-2 lidar instrument will be designed and tested at GSFC using component procurements from industry. The spacecraft vendor was competitively selected and the spacecraft bus will be procured via RSDO. The mission operations element will be provided by the spacecraft vendor via a contract option. The source and selection method for launch services will be determined during formulation.

MAJOR CONTRACTS/AWARDS

Element	Vendor/Provider	Location
Spacecraft	Orbital Sciences Corporation	Dulles, VA

INDEPENDENT REVIEWS

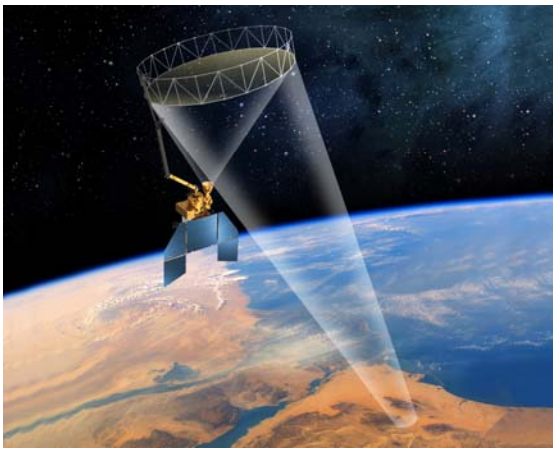
Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	New	Preliminary Design Review	Jun-12

SOIL MOISTURE ACTIVE AND PASSIVE (SMAP)

Formulation	Development	Operations

FY 2013 BUDGET

Budget Authority (in $ millions)	Prior	Actual FY 2011	Estimate FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**210.8**	**92.5**	**176.3**	**237.4**	**89.1**	**86.7**	**15.9**	**11.3**
Change From FY 2012 Estimate		--	--	**61.1**				
Percent Change From FY 2012 Estimate		--	--	**34.7%**				



SMAP has the potential to enable a diverse range of applications involving drought and flood estimation, agricultural productivity estimation, weather forecasting, climate modeling, and other factors affecting human health and security. For example, SMAP can benefit the emerging field of landscape epidemiology where direct observations of soil moisture can provide valuable information on vector population dynamics, such as identifying and mapping habitats for mosquitoes that spread malaria.

PROJECT PURPOSE

SMAP project is one of four first-tier missions recommended by the National Academies. SMAP data have both high science value and high applications value. The accuracy, resolution, and global coverage of SMAP soil moisture and freeze/thaw measurements are unprecedented and will enable new developments across many science and applications disciplines including hydrology, climate, carbon cycle, and the meteorological, environmental and ecology applications communities. The SMAP data, when assimilated into existing and updated Earth system science models, will lead to improved weather forecasts, flood and drought forecasts, and predictions of agricultural productivity and climate change, as well as improved understanding of the sources and sinks of carbon.

Future water resources are a critical societal impact of climate change, and scientific understanding of how such change may affect water supply and food production is crucial for policy makers. Current climate models' uncertainties result in disagreement on whether there will be more or less water regionally compared to today. SMAP data will help enable climate models to be brought into agreement on future trends in water resource availability. For these reasons, the Committees Water Resources Panel gave SMAP the highest mission priority within its field of interest.

SMAP will provide a capability for global mapping of soil moisture and freeze/thaw state with unprecedented accuracy, resolution, and coverage. SMAP science objectives are to acquire space-based hydrosphere state measurements over a three-year period to:

SOIL MOISTURE ACTIVE AND PASSIVE (SMAP)

Formulation	Development	Operations

- Understand processes that link the terrestrial water, energy and carbon cycles;
- Estimate global water and energy fluxes at the land surface;
- Quantify net carbon flux in boreal landscapes;
- Enhance weather and climate forecast skill; and
- Develop improved flood prediction and drought monitoring capabilities.

For more information, see: http://smap.jpl.nasa.gov.

EXPLANATION OF PROJECT CHANGES

Potential launch vehicle cost increases have resulted in the need to increase the projects life cycle cost estimate in FY 2013 to FY 2016.

PROJECT PRELIMINARY PARAMETERS

The SMAP observatory employs a dedicated spacecraft and will be launched into a near-polar, sun-synchronous orbit on an expendable launch vehicle. The SMAP baseline instrument suite includes a radiometer and synthetic aperture radar operating at L-band frequencies (1.215 to 1.427 gigahertz). The instrument is designed to make coincident measurements of surface emission and backscatter, with the ability to sense the soil conditions through moderate vegetation cover. The instrument measurements will be analyzed to yield estimates of soil moisture and freeze/thaw state. The measurement swath width is 1000 kilometers, providing global coverage within three days at the equator and two days at boreal latitudes (greater than 45 degrees North). Data will be acquired for a period of three years and a comprehensive validation program will be used to assess random errors and regional biases in the soil moisture and freeze/thaw estimates.

The standing review board will assess the design plan and cost/schedule estimates. Life cycle costs will be evaluated with respect to other Earth Systematic Missions and anticipated funding for FY 2013-1018. A decision on SMAP movement to development phase is expected in FY 2012.

ACHIEVEMENTS IN FY 2011

SMAP successfully passed the KDP-B review in January 2010, and is now in the formulation phase of the mission. The formulation phase emphasizes risk reduction and requirements and interface maturation. SMAP has completed preliminary designs for the flight system, instrument and spacecraft. The project has also built engineering models for most electronics systems and has initiated integrated tests of these systems.

SOIL MOISTURE ACTIVE AND PASSIVE (SMAP)

Formulation	Development	Operations

KEY ACHIEVEMENTS PLANNED FOR FY 2013

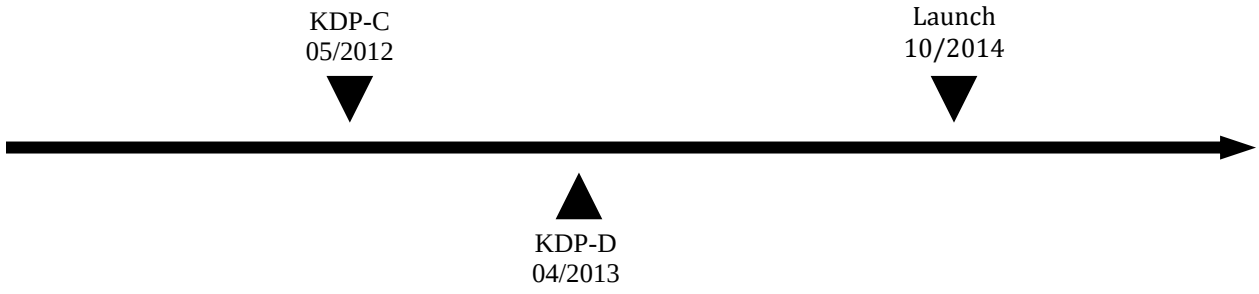
In FY 2013, SMAP will pursue development and implementation activities and milestone reviews, targeting an estimated launch in October, 2014. The project will also conduct the Systems Integration Review.

ESTIMATED PROJECT SCHEDULE

SMAP is scheduled to launch in October, 2014 for a three year prime mission.

Formulation Milestones	Formulation Agreement Estimate	FY 2013 PB Request Date
KDP-C	May-12	May-12
KDP-D	Apr-13	Apr-13
Launch	Oct-14	Oct-14

Project Schedule



SOIL MOISTURE ACTIVE AND PASSIVE (SMAP)

Formulation	Development	Operations

Formulation Estimated Life Cycle Cost Range and Schedule Range Summary

Life cycle cost estimates are preliminary and considered internal planning/management numbers. A baseline cost commitment does not occur until KDP-C.

KDPB Date	Estimated Life Cycle Cost Range ($M)	Key Milestone	Key Milestone Estimated Date Range
Jan-10	872-926	Launch Readiness	10/2014-1/2015

Project Management & Commitments

JPL has project management responsibility for SMAP.

Project Element	Provider	Description	FY 2012 PB	FY 2013 PB
Spacecraft	Provider: JPL Project Management: JPL NASA Center: JPL Cost Share: N/A	Provides platform for the instruments	Same	Same
L-Band SAR	Provider: JPL Project Management: JPL NASA Center: JPL Cost Share: N/A	Combined with Radiometer, provides soil moisture measurements in the top 5 cm of soil through moderate vegetation cover	Same	Same
L-Band Radiometer	Provider: GSFC Project Management: GSFC NASA Center: GSFC Cost Share: N/A	Combined with SAR provides soil moisture measurements in the top 5 cm of soil through moderate vegetation cover	Same	Same
Launch Vehicle	Provider: TBD Project Management: TBD NASA Center: KSC Cost Share: TBD	TBD	Same	Same

SOIL MOISTURE ACTIVE AND PASSIVE (SMAP)

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: launch service selection is not made, Then: it prevents definition of project baseline for KDP-C.	Project team is developing a strategy to preserve the observatory design and implementation schedule, while accommodating new Headquarters direction for launch services selection approach and timetable.

Acquisition Strategy

The deployable antenna/boom and instrument spin assemblies will be procured through open competition. The source and selection method for launch services will be determined later in formulation.

MAJOR CONTRACTS/AWARDS

None.

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Directorate Program Management Council (DPMC)	New	Successfully established an approach and timetable to achieve KDP-C.	Apr-12

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2013 BUDGET

	Actual	Estimate		Notional			
Budget Authority (in $ millions)	**FY 2011**	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**
FY 2013 President's Budget Request	**389.5**	**332.0**	**348.7**	**484.7**	**615.7**	**706.7**	**718.5**
Earth Systematic Mission Research	7.3	11.2	**9.1**	9.1	9.3	9.5	9.6
Ocean Surface Topography Science Team	5.4	6.3	**5.8**	6.0	6.1	6.3	6.4
Earth Observations Systems Research	25.2	25.8	**23.6**	24.1	24.5	25.3	25.5
Quick Scatterometer	3.6	3.6	**3.7**	3.8	3.9	3.9	4.0
TRMM	9.2	9.8	**10.2**	10.2	10.4	10.7	5.1
Decadal Survey Missions	72.8	107.7	**144.0**	279.6	407.3	493.7	509.7
Earth Science Program Management	26.8	38.0	**24.8**	24.9	25.4	28.2	27.5
OSTM	0.9	1.1	**1.2**	1.2	1.2	1.2	1.2
Precipitation Science Team	6.5	7.2	**7.2**	7.2	7.4	7.5	7.7
Ocean Vector Winds Science Team	3.2	4.7	**4.4**	4.4	4.5	4.6	4.7
Land Cover Science Program Office	1.5	1.5	**1.5**	1.5	1.6	1.6	1.6
Glory Mission	12.9	0.0	**0.0**	0.0	0.0	0.0	0.0
Suomi NPP	101.9	8.7	**7.0**	7.0	6.7	6.3	6.3
Terra	33.5	31.6	**32.4**	31.9	32.5	32.6	33.1
Aqua	32.5	32.2	**33.0**	33.0	34.2	35.0	35.4
Aura	29.7	28.3	**27.1**	26.8	27.7	28.4	28.7
ACRIMSat	1.3	1.3	**1.3**	1.3	1.4	1.4	1.4
SORCE	4.6	5.3	**5.2**	5.4	5.6	5.7	5.8
Jason	4.6	4.5	**4.6**	4.8	4.8	4.8	4.9
Earth Observing 1	2.5	2.4	**2.5**	2.5	1.3	0.0	0.0
ICESat	3.8	0.7	**0.0**	0.0	0.0	0.0	0.0
Change From FY 2012 Estimate	--	--	**16.7**				
Percent Change From FY 2012 Estimate	--	--	**5.0%**				

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

The ESM program includes missions from the former Earth Observing System (EOS) and the future Earth Science Decadal Survey (ESDS) missions. The artist's conception shows the complete armada of satellites, current and future, that contribute to the program's goals of understanding the Earth as a system (its water-air-land interactions).

ESM program provide critical, global earth science data ranging from ozone, aerosols, rainfall, ocean wave heights, winds, land and ice cover, forest canopy density, and earth radiation balance, etc. The ESM program includes instrument and mission science teams which define the scientific requirements for their respective instruments, and generate the algorithms used to process the data into useful data products for the investigations. The science teams are responsible for validating their own algorithms and data products. The research projects execute competitively selected ROSES investigations that are related to specific mission measurements.

Operating Missions

There are 11 operating missions within the ESM program. Each mission offers unique and critical science to the global community. Except for Suomi NPP, each of these missions is beyond its design life and has completed its prime operations phase. For missions in extended operations, NASA conducts a biennial Senior Review to identify those missions whose continued operation contributes cost-effectively to both NASA's goals and the Nation's operational needs. Such a review was conducted in 2011, using a panel of senior scientists drawn from the Earth Science community, and further supplemented by evaluations from partner agencies within the U.S. Federal and state governments. The 2011 Senior Review endorsed the continuation of all missions.

EARTH SYSTEMATIC MISSIONS RESEARCH

Earth Systematic Missions Research funds science teams for the Earth Systematic missions, currently the Suomi NPP mission. This is individual investigator competitively selected research to analyze data from the missions to address related science questions. In particular, the Suomi NPP science investigations are focused on developing climate data records from EOS observations continued by the NPOESS operational observing system.

OCEAN SURFACE TOPOGRAPHY MISSION (OSTM)

OSTM, or Jason-2, measures sea surface height, enabling scientists to assess climate variability and change and water and energy cycles. This mission is a follow-on to Jason, and recently completed its prime operations phase in June 2011. OSTM is a joint mission with NOAA, CNES, and EUMETSAT.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

EARTH OBSERVATION SYSTEMS (EOS)

EOS Research funds science for the EOS missions, currently Terra, Aqua, Aura, ICESat, and Landsat missions. These individual investigator, competitively selected research projects analyze data from the missions to address related science questions. Some funded projects continue algorithm improvement and validation for the EOS instrument data products, while overall the selected activities focus on science data analyses and the development of Earth system data records including climate data records, relevant to NASA's research program.

QUICK SCATTEROMETER (QUIKSCAT)

QuikSCAT carries the SeaWinds instrument, originally designed to measure global radar backscatter and ocean surface wind speed and direction under nearly all-weather conditions. Since the antenna stopped rotating in 2009, several years past its design life, the sensor has become the 'gold standard' for cross-calibration with other ocean wind scatterometers, enabling both the continuation of the high-quality ocean winds dataset and the operational forecasts. The 2011 Senior Review specifically endorsed the continuation of the mission with this cross-calibration objective.

TROPICAL RAINFALL MEASURING MISSION (TRMM)

TRMM measures precipitation, clouds, and lightning over tropical and subtropical regions and extends our knowledge about how the energy associated with rainfall interacts with other aspects of the global climate. The TRMM sensor suite provides a three-dimensional map of storm structure, yielding information on rain intensity and distribution. TRMM is a joint mission with Japan.

DECADAL SURVEY MISSIONS

Decadal Survey Missions contains missions recommended by the National Academies Earth Science decadal study, as well as a variety of climate change missions. All the projects within this line are either in early pre-Phase A early formulation work or still in the mission study phase. The current portfolio of missions includes the OCO-3 instrument, SWOT, PACE, ASCENDS, GEO-CAPE, ACE, and HyspIRI. It also contains funding for a potential Earth Radar Mission. While GRACE-FO and SAGE III have recently transitioned into formulation, their budgets are still retained in this project.

EARTH SCIENCE PROGRAM MANAGEMENT (ES PM)

ES PM supports the Center Earth Science Project Offices program management including the ESM Program Office at the GSFC, the Earth System Science Pathfinder (ESSP) Program Office at LaRC, and the Earth Science Flight Project Office at JPL. ES PM also supports the GSFC Conjunction Assessment

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Risk Analysis function, which performs analysis regarding maneuvers required to avoid potential collisions between instruments and to avoid debris; LaRC Committee on Earth Observation Satellites (CEOS), which provides technical and management support to the international Earth Satellite planning committee and facilitates the development of strategic space-based implementation plans using systems engineering methods; and Independent Program and Assessment Office, which supports the various project reviews for development projects in Earth Science.

OCEAN SURFACE TOPOGRAPHY SCIENCE TEAM

Ocean Surface Topography Science Team uses scientific data received from the OSTM and Jason satellites, which measures global sea surface height. Previously this project was associated with the Earth Systematic Missions area, wherein the OSTM mission is managed.

SUOMI NATIONAL POLAR ORBITING PARTNERSHIP (SUOMI NPP)

Suomi NPP extends selected scientific data sets initiated by the NASA Earth Observing System and serves as risk reduction demonstrations for key instruments to be used in the nation's future polar operational meteorological satellite systems. Suomi NPP launched in October 2011 to ensure critical continuity in the nation's operational meteorological measurements from the afternoon orbit. The five instruments on Suomi NPP will provide visible and infrared multi-spectral global imagery, atmospheric temperature and moisture profiles, total ozone and stratospheric ozone profiles, and measurements of Earth's radiation balance. In addition to a wide range of applications studies, the NASA science focus areas served by Suomi NPP will include: atmospheric composition climate variability and change carbon cycle, ecosystems, and biogeochemistry water and energy cycles, and weather.

NASA renamed the project on January 24, 2012, honoring the late Verner E. Suomi, a meteorologist at the University of Wisconsin who is recognized widely as "the father of satellite meteorology." The renaming also acknowledges the fact that the mission is the product of a partnership between NASA, NOAA, DoD, the private sector, and academic researchers.

PRECIPITATION SCIENCE TEAM

Precipitation Science Team uses scientific data received from the TRMM satellite to improve the forecasting of weather and severe storm events. Previously this project was associated with the Earth Systematic Missions area wherein the TRMM is managed. This science team also supports development of supporting algorithms for the GPM mission.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

OCEAN VECTOR WINDS SCIENCE TEAM

Ocean Vector Winds Science Team uses scientific data received from the QuickSCAT satellite, which measures ocean surface wind vectors by sensing ripples caused by winds near the ocean's surface. From these data, scientists can compute the winds' speed and direction, acquiring hundreds of times more observations of surface wind velocity each day than can ships and buoys. Previously, this project was associated with the Earth Systematic Mission area, wherein the QuikSCAT mission is managed.

THE LAND COVER PROJECT SCIENCE OFFICE (LCPSO)

GSFC works to maintain the science quality of satellite data used for land-cover/land-use change research. The focus of this office is on the moderate-resolution (<100m) sensors such as Landsat, and ALI and Hyperion on EO-1. They maintain over a 40-year calibration record for the Landsat-1 through Landsat-7 series of satellites. The office also provides community software tools to make it easier for users to work with moderate-resolution data. In collaboration with USGS, the Land cover Project Science Office supports improvements in the Landsat-7 Long-term Acquisition Plan and provision of preprocessed data sets for land-cover change analysis.

TERRA

Terra is one of the Earth Observing System flagship missions, carrying five instruments (MODIS, MISR, CERES, MOPITT, ASTER). It enables a wide range of interdisciplinary studies of atmospheric composition: carbon cycle, ecosystems, and biogeochemistry; climate variability and change; Earth's surface and interior; water and energy cycles; and weather. Terra is a joint mission with Japan and Canada.

AQUA

Aqua is one of the Earth Observing System flagship missions, carrying six sensors (MODIS, AMSR-E, CERES, and the AIRS/AMSU/HSB suite). Aqua improves our understanding of Earth's water cycle and the intricacies of the climate system by monitoring atmospheric, land, ocean, and ice variables. As part of the "Afternoon Constellation," Aqua is routinely evaluated as one of the most valuable of the Earth Science missions. During FY 2011, the AMSR-E antenna rotation stopped and analysis is currently in process to determine whether rotation can re-start. Aqua is a joint mission with Brazil and Japan.

AURA

Aura is the third of the Earth Observing System flagship missions, and carries four sensors, of which three remain functional (MLS, OMI, and TES). The mission enables study of atmospheric composition, climate variability and change, and weather, by measuring atmospheric chemical composition, tropospheric/stratospheric exchange of energy and chemicals, chemistry-climate interactions, and air

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

quality. Aura is also part of the "Afternoon Constellation," or A-Train. Aura is a joint mission with the Netherlands, Finland, and the United Kingdom.

ACTIVE CAVITY RADIOMETER IRRADIANCE MONITOR SATELLITE (ACRIMSAT)

ACRIMSat monitors total solar irradiance, contributing to assessments of climate variability and change.

SOLAR RADIATION AND CLIMATE EXPERIMENT (SORCE)

SORCE measures the total and spectral solar irradiance incident at the top of Earth's atmosphere, contributing to assessments of climate variability and change.

JASON

Jason makes precise measurements of ocean height to support the study of ocean circulation and sea level rise. The Jason mission is a collaboration between NASA and the Centre National d'Études Spatiales (CNES).

EARTH OBSERVING-1 (EO-1)

EO-1 allows paired scene comparisons of: carbon cycle, ecosystems, and biogeochemistry; and Earth surface and interior. It supports the dual data collection system of the EO-1 Advanced Land Imager and the Landsat-7 Enhanced Thematic Mapper Plus.

Recent Achievements

TERRA: HURRICANE KATIA

MODIS on NASA's Terra satellite captured this natural-color image at 11:15 a.m. Atlantic Standard Time on September 7. Hurricane Katia sports the spiral shape and distinct eye typical of strong storms. Data from instruments like MODIS are processed by NASA's Rapid Response system. Rapid Response provides daily MODIS images in near real time presented by geographic regions or orbit overpass time. The Rapid Response team is also developing an interactive Web Mapping Service that includes imagery from MODIS and other instruments.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

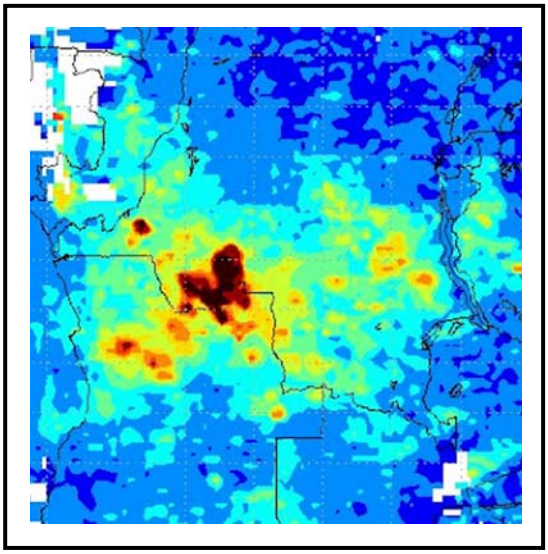
AQUA: MONITORING ARCTIC SEA ICE

Every year, the frozen Arctic Ocean emerges from winter and thaws under the 24-hour light of the summer sun. Each year is different: sometimes ice retreats from the shores in dramatic fashion and other years have a more gradual melt; 2011 proved to be a year of extreme melt. By early September, the area covered by sea ice in the Arctic Ocean was approaching a record low. This image is the last of a series of measurements taken by AMSR-E on NASA's Aqua satellite between March 7 and September 9. The image shows the sea ice at its lowest point so far this season. Most notably, the Northwest Passage, the sea route that threads through the islands of northern Canada to link the Atlantic and Pacific Oceans, is entirely ice free.

The last five years showed the lowest sea ice since records began in 1979, and according to climate experts, much of that trend has been caused by climate change.

AURA: ASSESSING FIRE AND SMOKE

This image from the OMI instrument on the Aura satellite shows nitrogen dioxide levels from July 7 to 12, 2011 in central Africa pertaining to agricultural fires. The highest levels of NO_2 appear as a dark red butterfly over the southern Democratic Republic of the Congo. Detection of NO_2 is important because it reacts with sunlight to create low-level ozone or smog and poor air quality. Low-level ozone (smog) is hazardous to the health of both plants and animals, and ozone in association with particulate matter causes respiratory problems in humans. Measurements like this help scientists predict poor air conditions and implement human safety countermeasures.

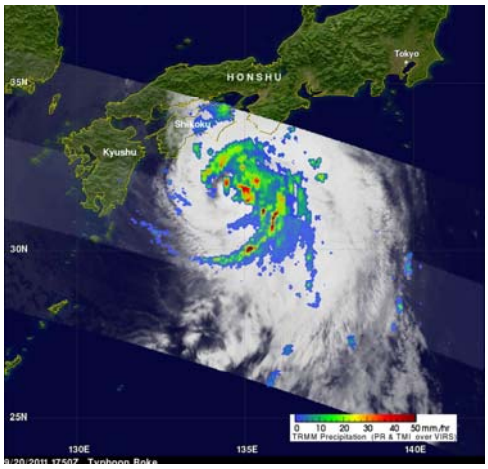


OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

TRMM: EARLY WEATHER WARNINGS

An array of passive microwave and active radar sensors on the TRMM satellite are valuable tools for observing tropical cyclones around the globe. TRMM captured this image of the typhoon, Roke, as it was nearing the Japanese coast. This image shows the horizontal pattern of rain intensity within the storm. Rain rates in the center swath are based on the TRMM Precipitation Radar , and those in the outer swath on the TRMM Microwave Imager. The rain rates are overlaid on visible and infrared data from the TRMM Visible Infrared Scanner.



SUOMI NPP WEATHER FORECASTING

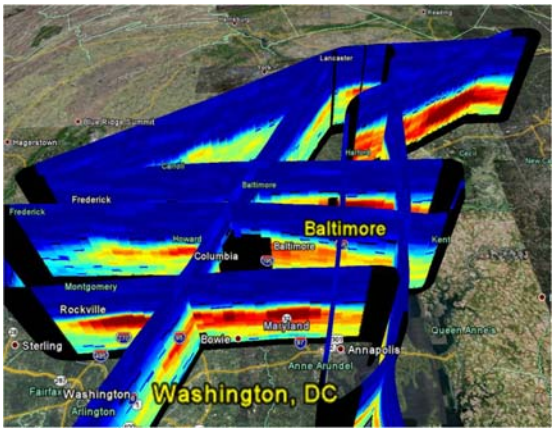
Suomi NPP successfully launched on October 28, 2011. Suomi NPP represents a critical first step in building the next-generation Earth-observing satellite system that will collect data on both long-term climate change and short-term weather conditions.

Suomi NPP will extend and improve upon the Earth system data records established by NASA's EOS fleet of satellites that have provided critical insights into the dynamics of the entire Earth system: clouds, oceans, vegetation, ice, solid Earth and atmosphere.

EARTH SYSTEM SCIENCE PATHFINDER

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**182.8**	**188.3**	**219.5**	**270.9**	**275.6**	**224.2**	**234.4**
OCO-2	89.0	98.4	**75.3**	57.9	45.4	16.0	4.0
Venture Class Missions	32.0	53.6	**106.2**	173.6	190.1	167.1	188.9
Other Missions and Data Analysis	61.7	36.3	**38.0**	39.4	40.1	41.1	41.5
Change From FY 2012 Estimate	--	--	**31.2**				
Percent Change From FY 2012 Estimate	--	--	**16.6%**				



Distinguishing between pollution high in the atmosphere and that near the surface where people live and breathe is one of the most challenging problems for Earth observations from space. An Earth Venture-1 project, DISCOVER-AQ, where AQ stands for air quality, is studying specific locations known for exceeding air quality standards, such as the Maryland-DC area shown. Instruments aboard research aircraft are essentially measuring gaseous and particulate pollution concentrations through a slice of air about two miles thick. The data, which is showing heavier concentrations toward the mid- to lower- portion of the slice, will be used to understand how satellites could make similar, consistent measurements over time. Potential outcomes such as better air quality forecasts and the ability to determine pollutant sources will help society deal more effectively with lingering pollution problems

Earth System Science Pathfinder (ESSP) provides an innovative approach to Earth science research by providing frequent, regular, competitively selected opportunities that accommodate new and emerging scientific priorities and measurement capabilities. These opportunities represent a series of relatively low-to-moderate cost, small-to-medium sized missions. They are competitively selected, principle investigator lead missions that focus on scientific objectives to support a selected subset of studies of the atmosphere, oceans, land surface, polar ice regions, or solid Earth. Projects include development and operation of space missions, space-based remote sensing instruments for missions of opportunity, and extended duration airborne science missions, and the conduct of science research utilizing data from these missions. ESSP projects include developmental, high-risk, high-return Earth science missions and often involve partnerships with other U.S. agencies and/or with international science and space organizations. This portfolio of missions and investigations provides opportunity for investment in innovative Earth science that enhances NASA's capability for better understanding the current state of the Earth system and to enable continual improvement in the prediction of future changes.

EARTH SYSTEM SCIENCE PATHFINDER

EXPLANATION OF MAJOR CHANGES FOR FY 2013

The increase in the ESSP program line has been driven by the expected increase in the launch vehicle cost for the OCO-2 mission, and the accompanying increase in the Project direct costs.

ACHIEVEMENTS IN FY 2011

All pre-flight operations were completed for Aquarius and the mission was launched in June 2011. Aquarius completed its instrument and satellite checkout period and began science operations in August 2011.

The Earth Venture 2 Announcement of Opportunity was made in Spring 2011; winning selections will be announced in early FY 2012.

All five Earth Venture 1 (EV-1) airborne science campaigns completed their confirmation reviews in FY2011 and moved into science operations phase. DISCOVER-AQ conducted its first series of flights in July 2011.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

In FY 2013, NASA will continue with results from all three legs of the Earth Venture line of competitive opportunities:

- Continuing with the second year of science data from the EV-1 investigations;
- Continuing in the formulation phase of the EV-2 small mission, which will have been selected in FY 2012;
- Evaluating and selecting winning proposal from the first EV-Instrument mission of opportunity; and
- Developing and releasing the second sub-orbital Earth Venture call, EV-3.

BUDGET EXPLANATION

The FY 2013 request is $219.5 million. This represents a $31.2 million increase from the FY 2012 estimate ($188.3 million).

This is primarily due to the increase to Venture Class funding resulting from increased EV2 orbital and EV-Instrument 1 suborbital activities, and additional funding for OCO-2 launch vehicle costs.

ORBITING CARBON OBSERVATORY 2 (OCO-2)

Formulation	Development	Operations

FY 2013 BUDGET

Budget Authority (in $ millions)	Prior	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017	LCC BTC	LCC Total
FY 2013 President's Budget Request	**91.1**	**89.0**	**98.4**	**75.3**	**57.9**	**45.4**	**16.0**	**4.0**	**0.0**	**477.2**
2012 MPAR Project Cost Estimate	**91.1**	**89.0**	**98.4**	**75.3**	**57.9**	**45.4**	**16.0**	**4.0**	**0.0**	**477.2**
Formulation	**60.9**	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	60.9
Development/ Implementation	**30.2**	89.0	**Under Review**							
Operations/close-out	0.0	0.0	**Under Review**							
Change From FY 2012 Estimate		--	--	**-23.1**						
Percent Change From FY 2012 Estimate		--	--	**-23.5%**						

EXPLANATION OF MAJOR CHANGES FOR FY 2013

The planned launch vehicle for the OCO-2 satellite was the Taurus XL. Following the Taurus XL failure in March 2011 and the loss of NASA's Glory mission, NASA put the contract for the Taurus XL on hold pending the outcome of a failure investigation. As a result, the planned OCO-2 launch readiness date will be changed. SMD has allocated additional budget to the OCO-2 mission in anticipation that the launch vehicle issues could delay the launch to 2015. The cost and schedule are currently under review.

PROJECT PURPOSE

Carbon dioxide is a critical component of the Earth's atmosphere. Since the beginning of the industrial age, the concentration of carbon dioxide has increased by about 38 percent. Scientific studies indicate that carbon dioxide is one of several gases that trap heat near Earth's surface. These gases are known as greenhouse gases. Most scientists have concluded that substantial increases in the abundance of carbon dioxide will generate an increase in the Earth's surface temperature. Historical records provide evidence of this trend, which is often called global warming (i.e., the overall increase Earth's surface temperature globally). Current research indicates that continuing increases in atmospheric carbon dioxide may modify the environment in a variety of ways. Although Earth's surface temperature may increase globally, specific regions on Earth may be affected differently. These changes may impact ocean currents, the jet stream, and rain patterns. Some parts of the Earth might actually cool while the average temperature increases. The purpose of the OCO-2 mission is to monitor one source of this climate change, carbon dioxide.

For more information see http://oco.jpl.nasa.gov/.

ORBITING CARBON OBSERVATORY 2 (OCO-2)

Formulation	Development	Operations

OCO-2 is designed to make space-based measurements of atmospheric carbon dioxide (CO2), an important greenhouse gas emitted by natural and man-made sources. The global coverage, spatial resolution, and accuracy of OCO-2 measurements will provide a basis to characterize and monitor the geographic distribution of where CO2 is emitted (sources) and absorbed (sinks), and quantify their variability. The gas is absorbed by the planet's oceans and plants, but the mystery is that only about half of the CO2 that doesn't remain in the atmosphere can be accounted for by these sinks. Dubbed "missing sinks," detection and understanding of these unknown absorption processes are a key target of observations.

PROJECT PARAMETERS

The OCO-2 spacecraft will carry three high-resolution grating spectrometers and fly in the "A-train" of Earth observing satellites. By using this space-based platform, OCO-2 will collect high-resolution measurements, which will provide a greater spatial distribution map of carbon dioxide over the entire globe. These measurements will be combined with data from ground-based networks to provide scientists with the information that they need to better understand the processes that regulate atmospheric carbon dioxide and its role in the carbon cycle. This enhanced understanding is essential for improving predictions of future atmospheric carbon dioxide increases and its impact on Earth's climate. This information will help policy makers and business leaders make better decisions to ensure climate stability and retain quality of life.

ACHIEVEMENTS IN FY 2011

In FY 2011 the OCO-2 project completed the assembly of all instrument subsystems, as well as most spacecraft subsystems. The project initiated spacecraft integration in August 2011. OCO-2 also initiated instrument integration in August 2011 and remains on schedule for instrument delivery in April 2012.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

In FY 2013 the OCO-2 project will complete observatory integration and testing, and deliver the craft to environmentally controlled stable storage in early FY 2013. It will stay in storage until some time prior to the revised launch date, when it will be taken out for completion of environmental testing and readiness for flight. The mission launch date will be defined when the launch vehicle is defined in FY 2012.

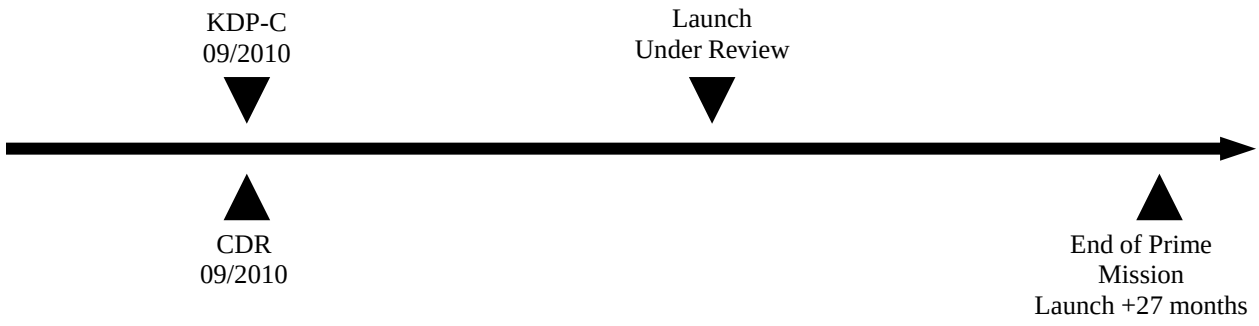
ORBITING CARBON OBSERVATORY 2 (OCO-2)

Formulation	Development	Operations

SCHEDULE COMMITMENTS/KEY MILESTONES

Development Milestones	Confirmation Baseline Date	FY 2013 PB Request Date
KDP-C	Sep-10	Same
CDR	Sep-10	Same
Launch	Feb-13	Under review
End of Prime Mission	Jun-15	Launch + 27 months

Project Schedule



ORBITING CARBON OBSERVATORY 2 (OCO-2)

Formulation	Development	Operations

Development Cost and Schedule

With the delay associated with the new approach to the launch vehicle, NASA will have to revisit the project plan and its associated costs and launch date.

Base Year	Base Year Development Cost Estimate ($M)	JCL (%)	Current Year	Current Year Development Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
2011	249	70	2012	under review	under review	LRD	Feb-13	under review	under review

Note: *The confidence level estimates reported reflect an evolving process as NASA improves its probabilistic estimation techniques and processes. The estimate above reflects the practices and policies at the time it was developed. Estimates that include combined cost and schedule risks are denoted as joint confidence level; all other confidence levels reflect cost confidence without necessarily factoring the potential impacts of schedule changes on cost.*

Development Cost Details (in $M)

Element	Base Year Development Cost Estimate	Current Year Development Cost Estimate	Change from Base Year Estimate
TOTAL:	**249.0**	**under review**	**under review**
Aircraft/Spacecraft	42.0	under review	under review
Payloads	39.4	under review	under review
Systems I&T	2.4	under review	under review
Launch Vehicle	67.6	under review	under review
Ground Systems	7.5	under review	under review
Science/Technology	10.0	under review	under review
Other Direct Project Costs	80.1	under review	under review

ORBITING CARBON OBSERVATORY 2 (OCO-2)

Formulation	Development	Operations

Project Management & Commitments

JPL has project management responsibility for OCO-2. OCO-2 was procured as a single source selection, in order to maintain the same configuration as the previous mission, OCO.

Project/Element	Provider	Description	FY 2012 PB	FY 2013 PB
OCO-2 instrument	Provider: JPL Project Management: JPL NASA Center: JPL Cost Share partner: None	Three channel, high-resolution grating spectrometer measuring carbon dioxide and diatomic oxygen near-infrared absorptions from reflected	Same	Same
Spacecraft	Provider: Orbital Project Management: JPL NASA Center: JPL Cost Share partner: None	Provides platform for the instrument.	Same	Same
Ground system	Provider: Orbital Project Management: JPL NASA Center: JPL Cost Share partner: None	Provides mission operations for satellite	Same	Same
Launch vehicle	Provider: Under review Project Management: KSC NASA Center: KSC Cost Share partner: None	Launch vehicle under review following failure of Glory Taurus XL	Taurus XL	Under review

ORBITING CARBON OBSERVATORY 2 (OCO-2)

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: Single string component failure, Then: Potential loss of mission.	OCO-2 (based on the competed OCO design) was designed to have some single string components. Thorough analyses and testing is being performed to mitigate this risk as much as possible.
If: Suspension of Launch Vehicles activities, Then: Delay of launch; with a potential cost increase.	OCO-2 launch vehicle activities have been suspended until completion of the Glory Mishap Investigation. Based on the results of the investigation NASA will make decisions on the OCO-2 launch vehicle.

Acquisition Strategy

MAJOR CONTRACTS/AWARDS

Element	Vendor/Provider	Location
Spacecraft	Orbital Sciences Corporation	Dulles, VA

ORBITING CARBON OBSERVATORY 2 (OCO-2)

Formulation	Development	Operations

INDEPENDENT REVIEWS

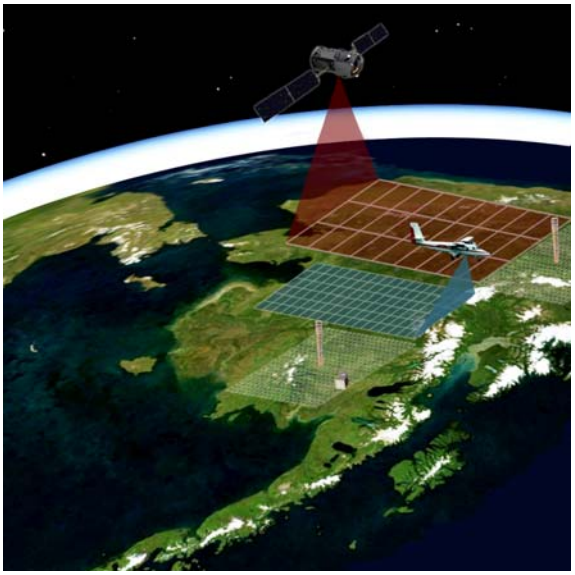
Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	Aug-10	SIR/CDR will determine readiness to proceed to Observatory-level integration and test.	Feb-12
Performance	SRB	N/A	ORR/Determine readiness of project to support mission operations prior to launch.	Nov-12
Performance	NASA HQ	N/A	FRR/Determine readiness of project to proceed to launch.	Dec-12

VENTURE CLASS MISSIONS

Formulation	Development	Operations

FY 2013 BUDGET

Budget Authority (in $ millions)	Prior	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**6.3**	**32.0**	**53.6**	**106.2**	**173.6**	**190.1**	**167.1**	**188.9**
Change From FY 2012 Estimate		--	--	**52.6**				
Percent Change From FY 2012 Estimate		--	--	**98.1%**				



Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) airborne observations over Alaska will be integrated with data from strategically located ground-based sites, as depicted in the artist concept. CARVE science fills a critical gap in Earth science knowledge on the fundamental elements of the complex Arctic biological-climatologic-hydrologic system.

The Venture Class Missions consists of a series of new science-driven, competitively selected, low cost missions that will provide opportunity for investment in innovative Earth science to enhance our capability to better understand the current state of the Earth system and to enable continual improvement in the prediction of future changes.

NASA's Venture Class Missions are a series of uncoupled, relatively low-to-moderate cost, small to medium-sized, competitively selected, full orbital missions, instruments for orbital missions of opportunity and sub-orbital projects.

Venture Class Missions have been established to respond to recommendations in the Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond (The National Academies Press, 2007) to initiate a series of missions deemed "venture class". The Venture Class Missions formulation activities have resulted in a scientifically broad-reaching program element that will solicit, through a series of frequent openly competed solicitations, innovative research and application missions that might address any area of Earth science. Solicitations for competitive, peer-refereed proposals will alternate between space-borne and airborne/suborbital opportunities.

VENTURE CLASS MISSIONS

Formulation	Development	Operations

The current Venture Class missions include Earth Venture-1 selections:

- Airborne Microwave Observatory of Subcanopy and Subsurface (AirMOSS) addresses the uncertainties in existing estimates by measuring soil moisture in the root zone of representative regions of major North American ecosystems;
- Airborne Tropical Tropopause Experiment (ATTREX) studies chemical and physical processes at different times of year from bases in California, Guam, Hawaii, and Australia;
- Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) collects an integrated set of data that will provide experimental insights into Arctic carbon cycling, especially the release of the important greenhouse gases such as carbon dioxide and methane;
- Deriving Information on Surface Conditions from COlumn and VERtically Resolved Observations Relevant to Air Quality (DISCOVER-AQ) improves the interpretation of satellite observations to diagnose near-surface conditions relating to air quality; and
- Hurricane and Severe Storm Sentinel studies hurricanes in the Atlantic Ocean basin using two NASA Global Hawks flying high above the storms for up to 30 hours.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

None

ACHIEVEMENTS IN FY 2011

The EV-2 Announcement of Opportunity was made in spring 2011; winning selections will be announced in early FY 2012.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

In FY 2013, NASA will produce results from all three legs of the Earth Venture line of competitive opportunities:

- Continue with the second year of science data from the EV-1 investigations;
- Continue the formulation phase of the EV-2 small mission, which will be selected in FY 2012;
- Evaluate and select the winning proposal from the first EV-Instrument mission of opportunity; and
- Develop and release the second sub-orbital Venture call, EV-3.

BUDGET EXPLANATION

The FY 2013 request is $106.2 million. This represents a $52.6 million increase from the FY 2012 estimate ($53.6 million).

VENTURE CLASS MISSIONS

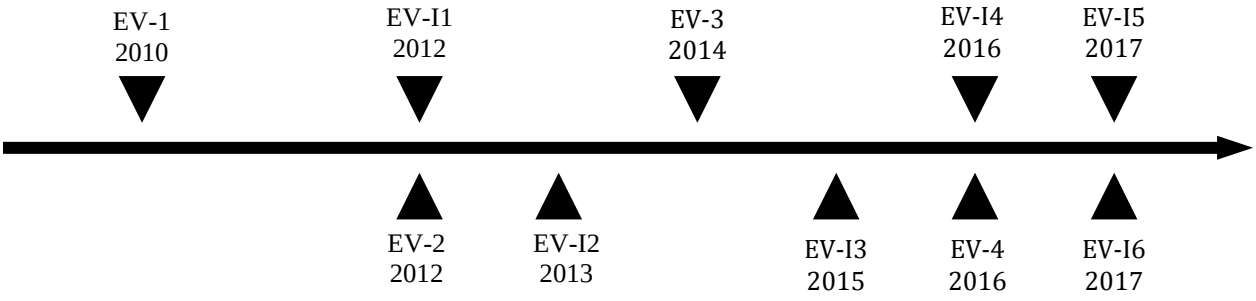
Formulation	Development	Operations

The project workforce is increasing, in preparation for more Venture missions and instruments reaching development.

SCHEDULE COMMITMENTS/KEY MILESTONES

Mission	Type of Mission	Selection Date	Est.	Major Milestone
EV-1	Suborbital	2009	2010	N/A
EV-2	Full Orbital	2011	2012	LRD ~2017
EV-Instrument 1	Instrument Only	2011	2012	Deliver ~2017
EV-Instrument 2	Instrument Only	2013	2013	Deliver ~2018
EV-3	Suborbital	2013	2014	N/A
EV-Instrument 3	Instrument Only	2014	2015	Deliver ~2018
EV-Instrument 4	Instrument Only	2015	2016	Deliver ~2019
EV-4	Full Orbital	2015	2016	LRD ~2021
EV-Instrument 5	Instrument Only	2016	2017	Deliver ~2020
EV-Instrument 6	Instrument Only	2017	2017	Deliver ~2021

Project Schedule



VENTURE CLASS MISSIONS

Formulation	Development	Operations

Project Management & Commitments

The Venture class of missions are managed within the ESSP program, managed out of the LaRC program office. Program management responsibility for implementation has been assigned to the ESSP Program Manager, located at LaRC; the LaRC Center Director is responsible for providing the Center resources required to execute the program. Programmatic authority is delegated from the SMD Associate Administrator to the ESD Director to the Associate Director for Flight Programs to the ESSP Program Manager. The program office oversees projects' implementation to ensure technical, cost, and schedule commitments are met, and advocates for projects with ESD and SMD.

Project/Element	Provider	Description
AirMoss	Provider: U Mich/JPL Project Management: LaRC NASA Center: LaRC Cost Share: None	Soil Moisture
ATTREX	Provider: ARC Project Management: ARC NASA Center: ARC Cost Share: None	Temporal changes in chemical and physical processes
CARVE	Provider: JPL Project Management: JPL NASA Center: JPL Cost Share: None	Arctic carbon cycling.
DISCOVER-AQ	Provider: LaRC Project Management: LaRC NASA Center: LaRC Cost Share: None	Air quality monitoring
HS3	Provider: GSFC/ARC Project Management: GSFC/ARC NASA Center: GSFC/ARC Cost Share: None	Huricane and severe storms

VENTURE CLASS MISSIONS

Formulation	Development	Operations

Acquisition Strategy

It is anticipated that NASA will issue a solicitation for Venture-Class Missions every year, and that the program will have the following characteristics:

- The Venture-class mission series will incorporate an optimal mix of suborbital (airborne) missions, small space-based missions and instruments of opportunity, which fly on a separately funded partner spacecraft;
- Venture-class missions will emphasize exploratory science results instead of technology demonstrations;
- The maximum development schedule for a Venture-class mission is five years for a satellite or instrument mission, with a shorter schedule for airborne/suborbital missions; and
- Venture-class missions will be capped at $150 million for a satellite mission, which includes launch vehicle costs. Solicitations for airborne/sub-orbital missions, instruments or missions of opportunity selected within the total cap from each solicitation.

MAJOR CONTRACTS/AWARDS

None.

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	N/A	EV-2 KDP-B/ Enter preliminary design phase.	Mar-12

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**61.7**	**36.3**	**38.0**	**39.4**	**40.1**	**41.1**	**41.5**
ESSP Missions Research	13.3	14.0	**13.4**	13.9	14.2	14.6	14.8
Aquarius	28.1	0.1	**4.7**	5.5	5.4	5.6	5.6
GRACE	4.5	5.2	**5.0**	5.1	5.2	5.3	5.4
Cloudsat	9.0	10.5	**8.2**	8.2	8.3	8.5	8.6
CALIPSO	6.7	6.5	**6.6**	6.8	6.9	7.1	7.2
Change From FY 2012 Estimate	--	--	**1.6**				
Percent Change From FY 2012 Estimate	--	--	**4.5%**				

Earth System Science Pathfinder program's cadre of satellites represents missions characterized by innovative design and relatively rapid implementation. These are focused missions that uniquely examine important components and physical processes within the global climate systems, including atmospheric carbon dioxide distribution, sea surface salinity variation, mass water movement, and the vertical structure of clouds and aerosols.

The ESSP program provides opportunities that represent a series of relatively low-to-moderate cost, small-to-medium sized, competitively selected, principle investigator-led missions. They are an innovative approach to Earth science research, providing periodic, competitively selected opportunities that accommodate new and emerging scientific priorities, and focused scientific objectives, supporting a subset of studies of the atmosphere, oceans, land surface, polar ice regions, or solid Earth.

Projects include development and operation of space missions, space-based remote sensing instruments for missions of opportunity and airborne science missions, and the conduct of science research utilizing data from these missions. ESSP Projects include developmental, high-risk, high-return Earth Science missions and often involve partnerships with other U.S. agencies and/or with international science and space organizations. These missions consist of a series of new science-driven, competitively selected, low cost missions that will provide innovative Earth science to enhance understanding of the current state of the Earth system and to enable continual improvement in the prediction of future changes.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Operating Missions

ESSP currently has four operating missions: GRACE, CloudSat, CALIPSO, and Aquarius. Aquarius is the only mission in prime operations, having been launched in June 2011. The other three missions are all in extended operations. All three participated in the 2011 Earth Science Division Senior Review for mission extension, and were endorsed officially for extension through 2013 and preliminary through 2015. These three missions are also expected to participate in the next Senior Review in 2013.

ESSP MISSIONS RESEARCH

ESSP Missions Research provides funds for the science teams for the ESSP missions. The science teams are comprised of competitively selected individual investigators who analyze data from the missions to address the related science questions.

AQUARIUS

Aquarius, launched in June 2011, has a three-year mission life. Aquarius will observe and model seasonal and year-to-year variations of sea-surface salinity and how these variations relate to changes in the water cycle and ocean circulation. The mission will provide the first global observations of sea surface salinity, covering Earth's surface once every seven days. In its three-year mission life, Aquarius will collect as many sea surface salinity measurements as the entire 125-year historical record from ships and buoys. The science focus areas served by Aquarius will include climate variability and change and water and energy cycles.

GRAVITY RECOVERY AND CLIMATE EXPERIMENT (GRACE)

The GRACE, launched in FY 2002, measures Earth's gravity field and its variations with time. GRACE consists of two spacecraft flying in tandem to measure Earth's gravitational field very precisely. These measurements enable a better understanding of ocean surface currents and ocean heat transport. The mission is able to measure changes in sea-floor pressure and show how the mass of the oceans change. It also measures and monitors ice sheets and changes in the storage of water and snow on the continents.

CLOUDSAT

CloudSat, launched in FY 2006 along with CALIPSO, measures cloud characteristics to increase understanding of the role of optically thick clouds in Earth's radiation budget. This mission specifically provides estimates of the percentage of Earth's clouds that produce rain, provides vertically-resolved estimates of how much water and ice are in Earth's clouds, and estimates how efficiently the atmosphere produces rain from condensates. CloudSat is collecting information about the vertical structure of clouds and aerosols unavailable from other Earth observing satellites. This data is improving our models and providing a better understanding of the human impact on the atmosphere. Policy makers and business

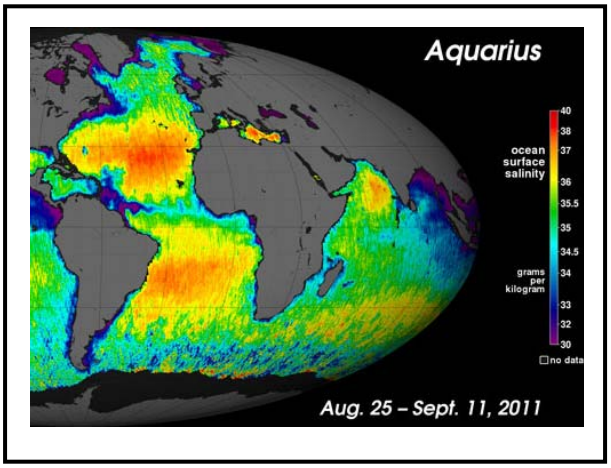
OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

leaders can make more informed long-term environmental decisions about public health and the economy and better day-to-day weather predictions will be possible as a result of these missions.

CLOUD-AEROSOL LIDAR AND INFRARED PATHFINDER SATELLITE OBSERVATION (CALIPSO)

CALIPSO launched in FY 2006 along with CloudSat, provides the next generation of climate observations, drastically improving the climate change prediction capabilities and to study breathable air. The mission provides statistics on the vertical structure of clouds, the geographic and vertical distribution of aerosols and detects subvisible clouds in the upper troposphere and polar stratospheric cloud. Also, the mission provides an indirect estimate of how much clouds and aerosols contribute to atmospheric warming. The CALIPSO payload consists of three co-aligned nadir-viewing instruments; the Cloud-Aerosol Lidar with Orthogonal Polarization, the Imaging Infrared Radiometer, and the Wide Field Camera.



Recent Achievements

AQUARIUS MAPS OCEAN SALINITY

Aquarius, which is aboard the Aquarius/Satélite de Aplicaciones Científicas (SAC-D) observatory, launched successfully June 10, 2011, from Vandenberg Air Force Base in California. Commissioning of the instrument began in August following final orbit maneuvers by the spacecraft, and science operations began August 25. The mission's first global map of ocean surface salinity was available approximately two weeks later. To produce the map, Aquarius scientists compared the early data with ocean surface salinity reference data. Although the early data contain some uncertainties, and months of additional calibration and validation work remain, scientists are impressed by the data's quality. The map shows several well-known ocean salinity features such as higher salinity in the subtropics; higher average salinity in the Atlantic Ocean compared to the Pacific and Indian oceans; and lower salinity in rainy belts near the equator, in the northernmost Pacific Ocean, and elsewhere. These features are related to large-scale patterns of rainfall and evaporation over the ocean, river outflow, and ocean circulation. Aquarius will monitor how these features change and study their link to climate and weather variations. Other important regional features are evident, including a sharp contrast between the arid, high-salinity Arabian Sea west of the Indian subcontinent, and the low-salinity Bay of Bengal to the east, which is dominated by the Ganges River and

south Asia monsoon rains. The data also show important smaller details, such as a larger-than-expected extent of low-salinity water associated with outflow from the Amazon River.

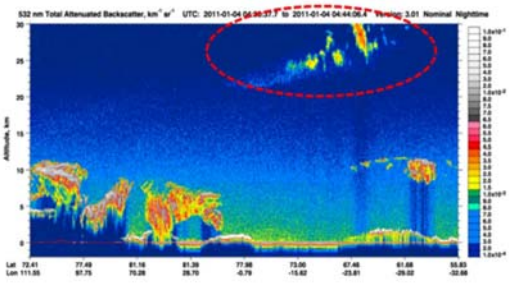
This artist's concept shows the CloudSat spacecraft and its extremely sensitive cloud profiling radar (CPR). Short pulses of microwave energy are sent down into the atmosphere, and by recording the way these pulses are scattered back to the satellite, the CPR generates a picture of the structure and water content of clouds, and in effect, allows scientists to weigh the clouds. Collecting information about the vertical structure of clouds is helping answer key questions about how they form, evolve and affect our weather, climate and water supply.

CLOUDSAT STUDIES CLOUD STRUCTURES

CloudSat is recovering from a severe battery anomaly, which occurred on April 17, 2011. The spacecraft lost one or more additional cells and required development of a new operational science mode. Recovery from the anomaly has been complicated by the need to maintain safe operations with the A-Train constellation of satellites (Aqua, Aura, CALIPSO, CloudSat, PARASOL), where CloudSat was in formation-flight with CALIPSO at the time of the anomaly. Following the contingency procedures developed by the A-Train Constellation mission operations managers, CloudSat exited the A-Train in late June and achieved a stable standby mode by late July. The mission team turned on the Cloud Profiling Radar for the first time since the anomaly on September 29, and after extended health assessment testing over the next month, determined that the radar is fully functional and capable of continuing the science mission. The mission transitioned to the new science "Daylight-Only" operating mode on November 2. Re-entry to the A-Train constellation or an alternative science orbit is still under analysis, and return to full science operations is anticipated in FY 2012.

CALIPSO OBSERVES RARE EVENT

CALIPSO observed an unusual mountain wave polar stratospheric cloud near the east coast of Greenland on January 4, 2011. Although orographically-induced wave ice PSCs are common in the Arctic (CALIPSO observes them every year), this event was remarkable because the cloud extended to altitudes above 30 kilometers. This is the highest wave ice polar stratospheric cloud observed by CALIPSO in the Arctic during its five-year mission. The propagation of mountain waves to such high altitudes is a rare



phenomenon that occurs about once per winter. On that day the tropospheric jet stream was aligned with the edge of the polar vortex, which produces ideal conditions for vertical mountain wave propagation.

EARTH SCIENCE MULTI-MISSION OPERATIONS

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**147.4**	**163.4**	**161.7**	**170.2**	**172.9**	**176.5**	**177.6**
Change From FY 2012 Estimate	--	--	**-1.7**				
Percent Change From FY 2012 Estimate	--	--	**-1.0%**				

The Earth Observing System Data and Information System (EOSDIS) is a major core capability within NASA's Earth Science Data Systems Program. EOSDIS ingests, processes, archives and distributes data from a large number of Earth observing satellites. EOSDIS consists of a set of processing facilities and Earth Science Data Centers distributed across the United States and serves hundreds of thousands of users around the world, providing hundreds of millions of data files each year covering many Earth science disciplines.

The Earth Science Multi-Mission Operations program acquires, preserves, and distributes observational data from operating spacecraft to support Earth Science focus areas in conformance with national science objectives. The Earth Science focus areas are: climate variability and change; atmospheric composition; carbon cycle, ecosystems, and biogeochemistry; water and energy cycles; weather; and Earth surface and interior.

NASA's principal Earth Science information system is EOSDIS, which has been operational since August 1994. EOSDIS acquires, processes, archives, and distributes Earth Science data and information products created from satellite data, which arrive at the rate of more than four trillion bytes (four terabytes) per day. Having successfully created this system, NASA is using IT advances to expand its capabilities while providing continuous service to the user community. The current budget request includes the Science Data Segment for Suomi NPP, and supports data archive and distribution for upcoming missions including OCO-2 and SMAP. EOSDIS project management is working with additional decadal survey mission teams to understand their mission data characteristics and guide further improvements and system evolution, in order to support new data types and better characterization (e.g. quantitative error information) of all NASA archived data. A system plan for 2015 and beyond will take into account evolutionary needs for new missions being developed in response to the National Academies decadal survey. These very modest investments will enable the system to keep technologically current, and incorporate new research data and services.

NASA Earth Science information is archived at eight Distributed Active Archive Centers (DAACs) and four disciplinary data centers located across the United States. The DAACs specialize by topic area, and make their data available to researchers around the world.

For more information, see: http://www.science.nasa.gov/earth-science/earth-science-data/.

EARTH SCIENCE MULTI-MISSION OPERATIONS

Research opportunities related to EOSDIS are available through NASA's ROSES announcements. For more information on the Advanced Collaborative Connections for Earth System Science (ACCESS) see http://science.nasa.gov/earth-science/earth-science-data/access/.

Research opportunities related to Making Earth System data records for Use in Research Environments (MEaSUREs) through NASA's ROSES announcements. For more information on MEaSUREs see http://science.nasa.gov/earth-science/earth-science-data/Earth-Science-Data-Records-Programs/#ESDR_in_research_environments.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

None.

ACHIEVEMENTS IN FY 2011

The successful completion of the Evolution of EOSDIS Elements effort has increased efficiency and operability and increased data usability by the research, application, and modeling communities. EOSDIS provides services and tools to enable use of NASA's Earth Science data in next-decadal models, research results, decision support system benchmarking, and improved support for end users.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

The FY 2013 request includes all the requirements for the operations and maintenance of the EOSDIS, including DAACs and Data Centers, the Science Investigator-led Processing Systems, the EOSDIS CORE system, Science Data Processing System, and all the accompanying infrastructure and functions; all post-launch requirements for Suomi NPP Science Data Processing System Product Evaluation and Analysis Tool Element product analysis support; post launch processing for Cloud and Earth Radiant Energy System (CERES) and Ozone Mapper Profile Suite (OMPS)-Limb; and support for development and operations of the Land Atmosphere Near real-time Capability for EOS (LANCE) near-real-time system.

The budget request for FY 2013 incorporates cost savings from EOSDIS and supports upcoming missions including OCO-2, SMAP, and GPM. EOSDIS project management is working with decadal survey mission teams to understand their mission data characteristics and guide further improvements and system evolution.

EARTH SCIENCE MULTI-MISSION OPERATIONS

BUDGET EXPLANATION

The FY 2013 request is $161.7 million. This represents a $1.7 million decrease from the FY 2012 estimate ($163.4 million).

This decrease is due to revised demand for the data centers and other multi-mission operations (MMO) support for delayed Earth science missions.

Projects

EARTH OBSERVING SYSTEM DATA AND INFORMATION SYSTEM (EOSDIS)

The EOSDIS project provides science data to a wide community of users, including NASA, Federal agencies, international partners, academia, and the public. EOSDIS provides users with the services and tools they need in order to use NASA's Earth science data in research and creation of next-decadal models. EOSDIS archives and distributes data through standardized science data products, using algorithms and software developed by Earth Science investigators.

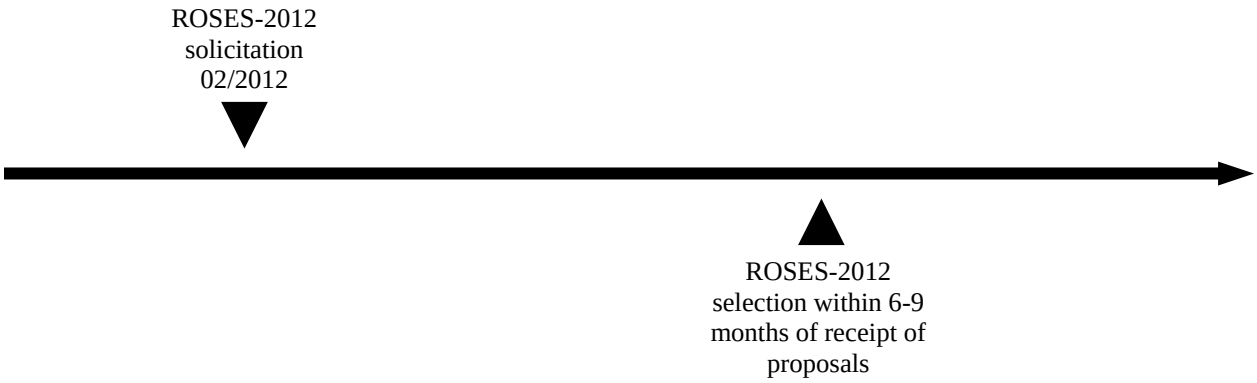
EARTH SCIENCE MULTI-MISSION OPERATIONS

This project funds the Elements of EOSDIS Evolution, aimed at improving the efficiency and effectiveness of EOSDIS while reducing the cost. It also supports the eight nationwide DAAC installations that collect, disseminate, and archive Earth science data. Each DAAC focuses on a specific Earth system science discipline and provides users with data products, services, and data-handling tools unique to that specialty:

- The Alaska Synthetic Aperture Radar Facility, which collects data and information on sea ice, polar processes, and geophysics;
- The GSFC Earth Sciences Data and Information Services Center, which collects information on atmospheric composition, atmospheric dynamics, global precipitation, ocean biology, ocean dynamics, and solar irradiance;
- The Langley Research Center DAAC, which collects data on Earth's radiation budget, clouds, aerosols, and tropospheric chemistry;
- The Land Processes DAAC, which collects land processes data;
- The National Snow and Ice Data Center, which collects snow and ice data, as well as information about the cryosphere and climate;
- The Oak Ridge National Laboratory DAAC, which collects data on biogeochemical dynamics and ecological data for studying environmental processes;
- The Physical Oceanography DAAC, which collects information on oceanic processes and air-sea interactions; and
- The Socioeconomic Data and Applications Center, covering population, sustainability, multilateral environmental agreements, natural hazards, and poverty.

EARTH SCIENCE MULTI-MISSION OPERATIONS

Program Schedule



Program Management & Commitments

The Science Mission Directorate and the Program Management Council have oversight responsibility for the program. The EOSDIS Project Office at GSFC has primary responsibility for day-to-day operations. DAACs are also co-located with other agencies (USGS-EDC, DOE-ORNL) and at the following universities: University of Alaska at Fairbanks, University of Colorado, and Columbia University.

Project/Element	Provider
EOSDIS core system, and Evolution of EOSDIS upgrades	Provider: GSFC Project Management: GSFC NASA Center: GSFC Cost Share: None
Distributed Active Archive Centers (DAACs)	Provider: GSFC Project Management: GSFC, each DAAC has local project management NASA Center: GSFC, LaRC, MSFC, JPL Cost Share: None
Precipitation Processing System (PPS)	Provider: GSFC Project Management: GSFC NASA Center: GSFC Cost Share: None
ACCESS, MEaSUREs	Provider: SMD Project Management: Selected via ROSES NASA Center: All Cost Share: None

EARTH SCIENCE MULTI-MISSION OPERATIONS

Acquisition Strategy

The EOSDIS Core System is a high-performance software system that provides science data ingest, archive and distribution capabilities for a multitude of Earth science instruments. Maintenance and operations for this system, utilized by three DAAC's post-Step 1 Evolution of EODIS Elements, is performed under contract procured by GSFC.

MAJOR CONTRACTS/AWARDS

None.

INDEPENDENT REVIEWS

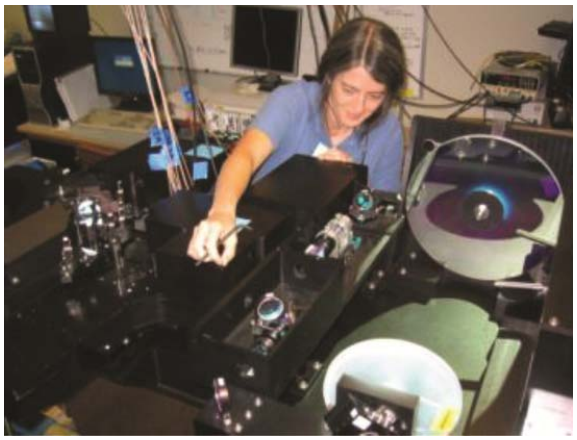
Independent reviews of customer satisfaction (the customers are the users of NASA Earth science data) are conducted by the American Consumers Satisfaction Index (ACSI) Survey. EOSDIS has been conducting the ACSI surveys of its data users annually since 2004.

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Survey	ASCI	2011	In addition to the company-level satisfaction scores, ACSI produces scores for the causes and consequences of customer satisfaction and their relationships.	2012

EARTH SCIENCE TECHNOLOGY PROGRAM (ESTP)

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**52.8**	**51.2**	**49.5**	**50.1**	**52.1**	**54.1**	**56.1**
Change From FY 2012 Estimate	--	--	**-1.7**				
Percent Change From FY 2012 Estimate	--	--	**-3.3%**				



During two weeks of ground testing in July 2011, the Optical Autocovariance Wind Lidar (OAWL) made line-of-sight aerosol wind measurements alongside a reference wind lidar from NOAA. OAWL flew several airborne validation tests in early FY 2012 onboard the NASA WB-57 aircraft. This emerging technology may enable a fundamentally new kind of spaceborne instrument for global measurements of wind speed and direction within the troposphere (the lowest 5 to 12 miles of the atmosphere) for the accurate, reliable, long-term weather forecasts of tomorrow.

Advanced technology plays a major role in enabling Earth research and applications programs by advancing understanding of the total Earth system and the effects of natural and human-induced changes on the global environment. ESTP enables previously unforeseen and previously infeasible science investigations; improves existing measurement capabilities; and reduces the cost, risk, and/or development times for Earth science instrumentation.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

None.

ACHIEVEMENTS IN FY 2011

In FY 2011, NASA continued to focus on priorities provided by the National Academies decadal survey and NASA's plan for climate-centric observations *Responding to the Challenge of Climate and Environmental Change*. During this period, NASA sponsored technology developments and prototype demonstrations for the majority of second-tier decadal missions and, in particular, produced a breakthrough development related to the proposed third-tier 3D-Winds mission.

This year 31 new investments were added to the Earth Science Technology Office (ESTO) portfolio by solicitations through the Instrument Incubator Program (IIP) and the Advanced Component Technologies (ACT) programs. Through these solicitations, NASA continues to build a strong history of technology development and infusion. During FY 2011, 50 percent of active technology projects advanced at least one Technology Readiness Level, and many projects achieved infusion into science measurements, system demonstrations, or other applications. Overall, of the more than 550 projects completed in the

EARTH SCIENCE TECHNOLOGY PROGRAM (ESTP)

portfolio, 36 percent have already been infused and an additional 44 percent have a path identified for future infusion.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

In FY 2013, ESTO will plan and develop new remote-sensing and information systems technologies for infusion into future science missions and airborne campaigns to enable, or dramatically enhance, measurements and data system capabilities. Planning starts with measurement priorities established by the science community, leading to systematically developed technology requirements and priorities. Studies may be conducted to assess measurement options for meeting technology performance requirements.

BUDGET EXPLANATION

The FY 2013 request is $49.5 million. This represents a $1.7 million decrease from the FY 2012 estimate ($51.2 million).

This is due to the reallocation of funding based on Agency priorities.

Projects

INSTRUMENT INCUBATOR

This element develops instrument and measurement techniques at the system level, including laboratory breadboards and operational prototypes for airborne validation. Currently, 37 IIP projects are funded. In this program, a significant investment is being made towards development of an accurate measurement technique for carbon dioxide, whereby several candidate instruments prototypes are under development. Another IIP project is developing technologies to enable measurement in a broad spectral range from ultraviolet to visible to infrared. IIP also supported the development of a unique type of lidar that could one day be used to make three-dimensional wind measurements.

In FY 2011, a novel system for future Doppler wind measurements completed an important ground demonstration that showed good correlation with a calibrated ground source. The Optical Autocovariance Direct Detection Wind Lidar offers a hybrid approach that uses a single 355-nm laser to measure winds from both aerosol and molecular backscatter. This single laser system has the potential to greatly simplify the sensor for, and reduce the cost of, the 3D-Winds mission.

EARTH SCIENCE TECHNOLOGY PROGRAM (ESTP)

ADVANCED INFORMATION SYSTEMS TECHNOLOGY

This element develops end-to-end information technologies that enable new Earth observation measurements and information products. The technologies are used to process, archive, access, visualize, communicate, and understand science data. Currently, 20 projects focus on three areas needed to support future Earth science measurements: Sensor System Support, which nurtures autonomy and rapid response in the sensing process to improve the science value of data; Advanced Data Processing, designed to enhance the information extracted from the data stream; and Data Services Management, whose investments manage the growing body of Earth science data and allow for efficient exchange. The active projects seek to reduce the cost and risk of future Earth Science missions. The most recent solicitation occurred under ROSES-2011; with selections expected in early 2012.

In FY 2011, NASA used the Real Time Mission Monitor (RTMM) for two field campaigns: the Light Precipitation Evaluation Experiment and the Winter Storms and Pacific Atmospheric Rivers experiment. RTMM is a tool that autonomously integrates data sets, weather information, vehicle operations data, and model and forecast outputs to help manage field experiments that involve a variety of space, airborne and ground assets. During both campaigns, RTMM optimized decision making by presenting timely data and visualizations and improving real-time situational awareness.

Processing strategies developed by the Multi-Sensor Data Synergy Advisor (MDSA) project are being used to improve the quality and usability of selected atmospheric data products from MODIS instruments onboard the Terra and Aqua satellites. MDSA is a series of tools that enable data access and interoperability, provide data provenance, and improve comparisons between data sets.

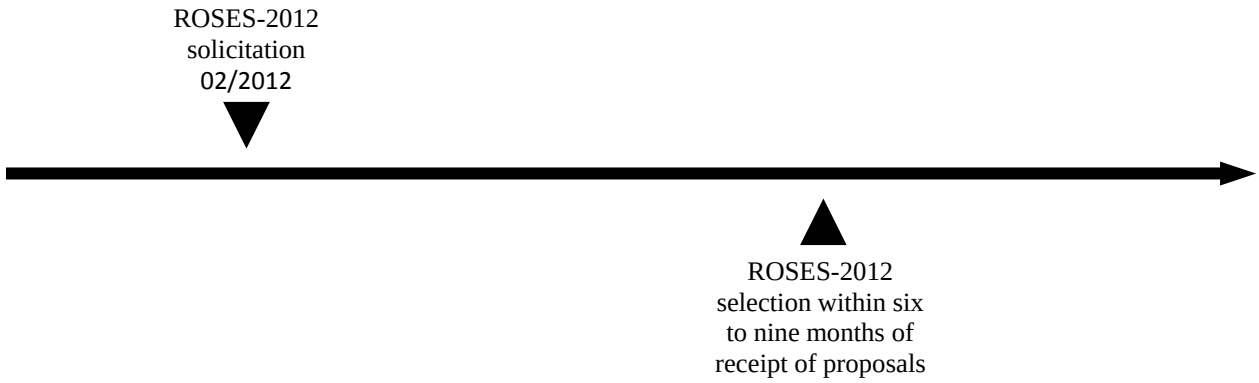
ADVANCED TECHNOLOGY INITIATIVES

The Advanced Technology Initiatives element enables development of critical component and subsystem technologies for instruments and platforms, mostly in support of the Earth science decadal survey. The most recent solicitation for advanced component technologies occurred under ROSES-2010, where 15 new selections were made that focused on areas such as space-qualified laser transmitters, passive optical technologies, and microwave and calibration technologies. Other awards support measurements of solar radiance, ozone, aerosols, and atmospheric gas columns for air quality and ocean color for coastal ecosystem health and climate emissions.

In FY 2011, the first airborne measurements of atmospheric oxygen in the 1.26 micron band were successfully demonstrated on board the NASA DC-8 aircraft. The all fiber-based transmitter demonstrated 1.5 watts of modulated continuous wave power and represents the first-ever modulated high power narrow line-width source at this wavelength. This accomplishment marks significant progress towards a key risk reduction for the oxygen component measurement recommended for the future global carbon dioxide sensing ASCENDS mission.

EARTH SCIENCE TECHNOLOGY PROGRAM (ESTP)

Program Schedule



Program Management & Commitments

ESTO at GSFC provides strategic, science-driven technology assessments and requirements development for the program. The office coordinates its technology investments with the Agency-wide technology program through the Science Mission Directorate's Assistant Director for Innovation and Technology, a member of the NASA Technology Executive Council.

Project/Element	Provider
Instrument Incubator	Provider: ESTO Project Management: ESTO NASA Center: GSFC, JPL, LaRC, ARC, GRC, JSC, DFRC Cost Share: None
Advanced Information Systems	Provider: ESTO Project Management: ESTO NASA Center: GSFC, JPL, LaRC, ARC, GRC, MSFC Cost Share: None
Advanced Technology Initiatives	Provider: ESTO Project Management: ESTO NASA Center: GSFC, JPL, LaRC Cost Share: None

EARTH SCIENCE TECHNOLOGY PROGRAM (ESTP)

Acquisition Strategy

ESTO will plan and implement development of new remote-sensing and information systems technologies for infusion into future science missions in order to enable, or dramatically enhance, measurements and data system capabilities. Tasks are procured primarily through full and open competition, such as the ROSES announcements.

In 2013, NASA will issue the next Instrument Incubator solicitation through the ROSES call for new instrument technologies including those that will support future decadal survey measurements. It is anticipated that individual awards will no exceed $4.5 million each for a three-year activity.

NASA will also continue supporting and managing awards made in the FY 2011 Advanced Information Systems Technology solicitation. Planning and preparations and will be made for issuing the next round of solicitation to be released in FY 2014.

Finally, in 2013 NASA will continue supporting and managing component technologies made in the FY 2010 Advanced Component Technology solicitation. Planning and preparations and will be made for issuing the next round of solicitation to be released in FY 2014.

INDEPENDENT REVIEWS

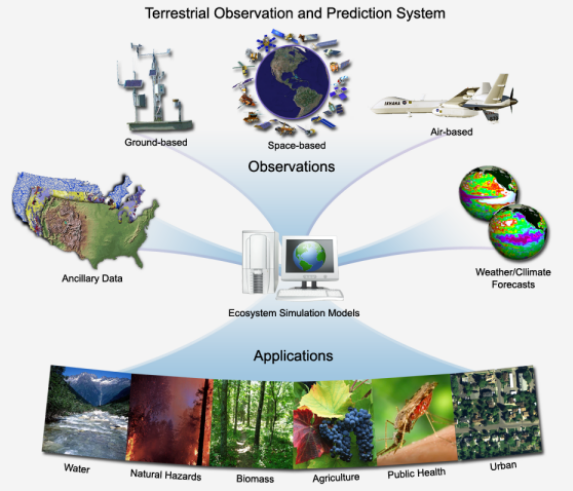
The performance of technology program activities is measured in multiple ways. NASA addresses several specific goals with associated outcomes in the NASA annual performance plan, which is outlined in a separate section. ESTP provides a summary of Government Performance and Results Act Modernization Act metrics and performance assessments in the ESTO Annual Report. Current and prior annual reports are available on the ESTO Web site at http://esto.nasa.gov/.

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Annual Technology Evaluation	NAC Earth Science Subcommittee	2009	The Earth Science Subcommittee reviewed the Earth Science Technology Program for infusion of new technologies and participation of universities in developing the new generation of technologists. The committee was overall pleased with the technology program; it wanted to ensure that tasks focus on being able to reduce cost in missions and are directed towards enabling/enhancing specific measurements.	2012

APPLIED SCIENCES

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**36.6**	**36.4**	**34.6**	**35.0**	**36.7**	**38.4**	**40.1**
Change From FY 2012 Estimate	--	--	**-1.8**				
Percent Change From FY 2012 Estimate	--	--	**-4.9%**				



The Program focuses on both applied research and targeted, decision-support projects in 9 areas of national priority: Disasters; Agriculture; Ecological Forecasting; Climate; Health & Air Quality; Energy; Water Resources; Oceans; and Weather.

The NASA Applied Sciences program leverages NASA Earth Science satellite measurements and new scientific knowledge to enable innovative and practical uses by public and private sector organizations. The Applied Sciences program supports applied research and applications projects to enable near-term uses of Earth science knowledge, discover and demonstrate new applications, and facilitate adoption of applications by non-NASA stakeholder organizations.

Applied research and applications projects are designed to improve decision-making activities to help the Nation better manage its resources, improve quality of life, and strengthen the economy. NASA develops Earth science applications in collaboration with end-users in public, private, and academic organizations.

Examples include: improved public health tracking systems for infectious diseases with the Centers for Disease Control; advances in accuracy of volcanic ash advisories for airplane pilots with the National Weather Service and the Federal Aviation Administration; improved wildfire smoke predictions with the U.S. Forest Service to reduce downwind public exposure; advances in assessing impacts of climate change on U.S. National Park ecosystems and improving land management strategies; improved assessment of flooding and landslide conditions with International Red Cross to plan mitigation and response activities; development of drought indicators with National Drought Mitigation Center to support end users' conservation and agriculture decisions; and international disaster management support with the U.S. Agency for International Development (USAID).

The program's primary outcomes are the routine, sustained uses of NASA Earth science products in user organizations' policy, business, and management decisions to serve society; the impacts are the resulting socioeconomic benefits from the improved decisions. The program enables operational users to imagine and anticipate possible applications from upcoming satellite missions and to provide input to mission development teams to increase the societal benefits of NASA missions.

APPLIED SCIENCES

EXPLANATION OF MAJOR CHANGES FOR FY 2013

None.

ACHIEVEMENTS IN FY 2011

In FY 2011, under Applied Sciences, scientists demonstrated reliable detection of volcanic ash clouds using Aura/OMI SO2 data and other NASA Earth science satellites. Products from these sensors were used by NOAA to formulate and produce volcanic ash advisories for aviators across the Gulf of Mexico due to the February 2011 eruption of the Popocatepetl volcano in Mexico.

GRACE satellite data was used to provide insights into subsurface water fluctuations at regional to national scales. The National Drought Mitigation Center monitors the Nations drought conditions (and publishes a Drought Monitor) and now distributes three maps each week based on the GRACE satellite data. One shows long-term fluctuation in deep groundwater, another shows change down to a meter below the surface, and a third shows change in the top two centimeters. Efforts in FY 2012 and FY 2013 will build on these achievements and lead to more accurate drought assessments, ultimately benefitting the many stakeholders who depend on the assessments.

The SERVIR activity within Applied Sciences developed a series of satellite-based products used by the government of the Dominican Republic and USAID prior, during, and after tropical storm Emily. Emily was the fiftieth extreme event (since 2004) for which NASA provided SERVIR assistance to Latin America and the Caribbean.

As part of an Administration pilot program for impact evaluations, the program completed impact analyses of two projects during FY 2011 to assess the change in decision-making performance by partner organizations through the use of NASA Earth science data.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

A set of applications will provide NASA with feasibility studies in the areas of water resources, wildfires, and disasters. To increase focus on high-reward projects, the Applied Science program will down-select the studies and fund a sub-set in each area that will proceed to three-year implementation projects. The program will issue new project solicitations in FY 2013, particularly to enable use of the Suomi NPP and LDCM satellites and to prepare applications for SMAP and ICESat-2 missions.

NASA will deliver a risk assessment project on changes in the Himalayan glaciers. This project will apply Earth observations on impacts of glacier change to water availability, management of water resources, and decision making related to flooding and agriculture. NASA, in conjunction with other interested agencies, will initiate up to three new hubs (selected in FY 2012) to expand the SERVIR program and advance the use of Earth observations to serve U.S. international development interests.

APPLIED SCIENCES

BUDGET EXPLANATION

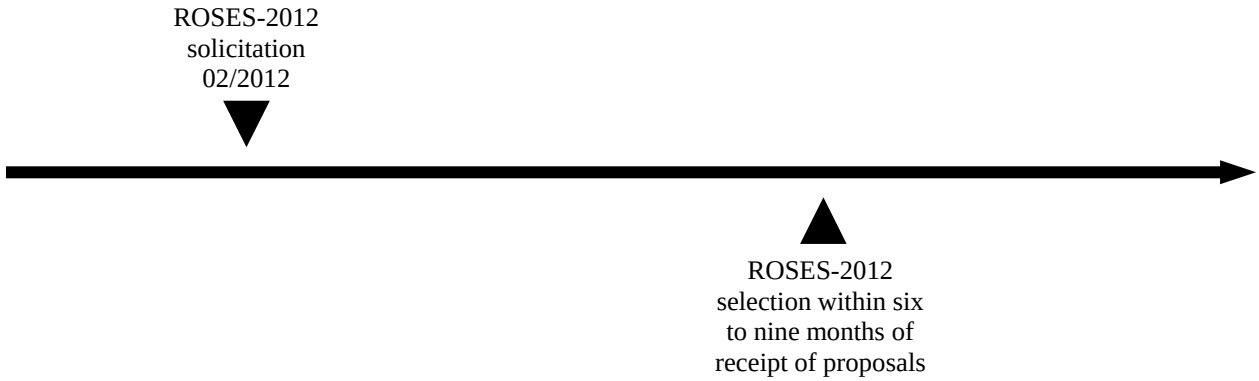
The FY 2013 request is $34.6 million. This represents a $1.8 million decrease from the FY 2012 estimate ($36.4 million).

This is due to the reallocation of funding based on Agency priorities.

Projects

Pathways has two primary lines of business, Applications and Capacity Building. The Applications themes are Health and Air Quality, Disasters, Ecological Forecasting, and Water Resources, including climate-related influences and impacts within each of these themes. The Capacity Building elements focus on foreign and domestic activities to build skills and capabilities in uses of Earth observations, including international and economic development.

Program Schedule



APPLIED SCIENCES

Program Management & Commitments

The Applied Sciences program responsibility resides within the Earth Science Division of the Science Mission Directorate. The program also has collaborations with state agencies; regional organizations, such as Western Governors' Association, and Gulf of Mexico Alliance; and non-profit intergovernmental organizations, such as United Nations Food and Agricultural Organization.

Project/Element	Provider
Earth Science Applications	Provider: SMD Project Management: NASA HQ NASA Center: GSFC, LaRC, SSC, JPL, MSFC, and ARC Cost Share: EPA, NOAA, USDA, USGS, NPS, USFWS, CDC, USAID

Acquisition Strategy

The Earth Science Applied Science acquisitions are based on full and open competition. Grants are peer reviewed and selected based on NASA research announcements and other related announcements. The program emphasizes cost sharing in projects, especially with Decision Support projects, which incorporate Earth science applications into decision making for societal benefit.

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	NRC	Oct-07	The Applied Sciences program strategy and implementation.	2013
Relevance	Applied Sciences Analysis Group	Nov-10	Applied Sciences program strategy and implementation. Annual reports to NASA Advisory Council from its Earth Science Subcommittee.	2012